Materials Engineering in Product Design & Manufacture

Materials & Methods

September 1955

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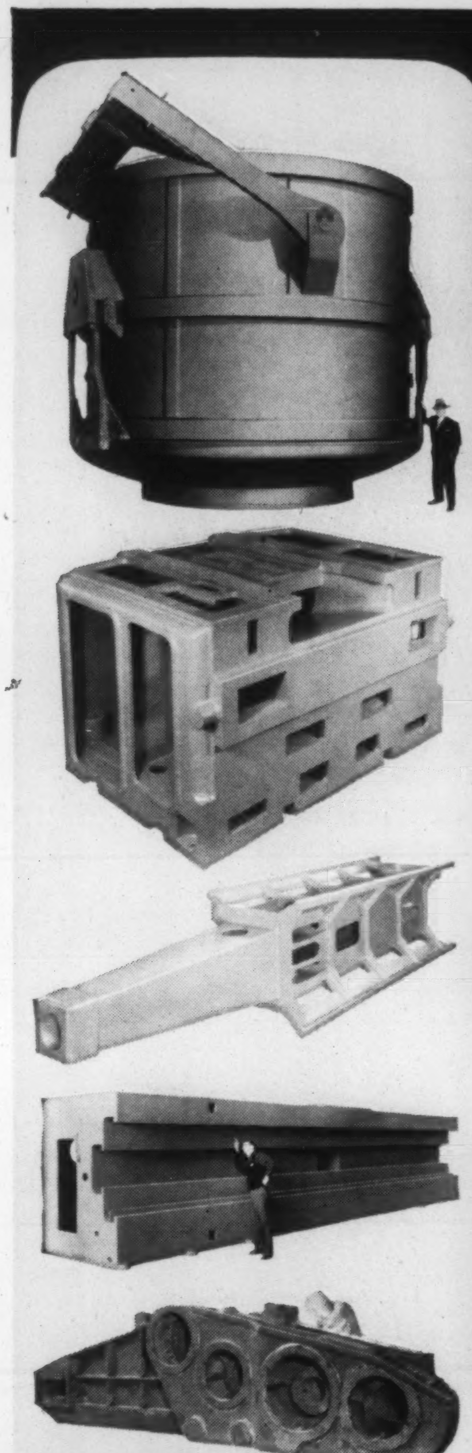

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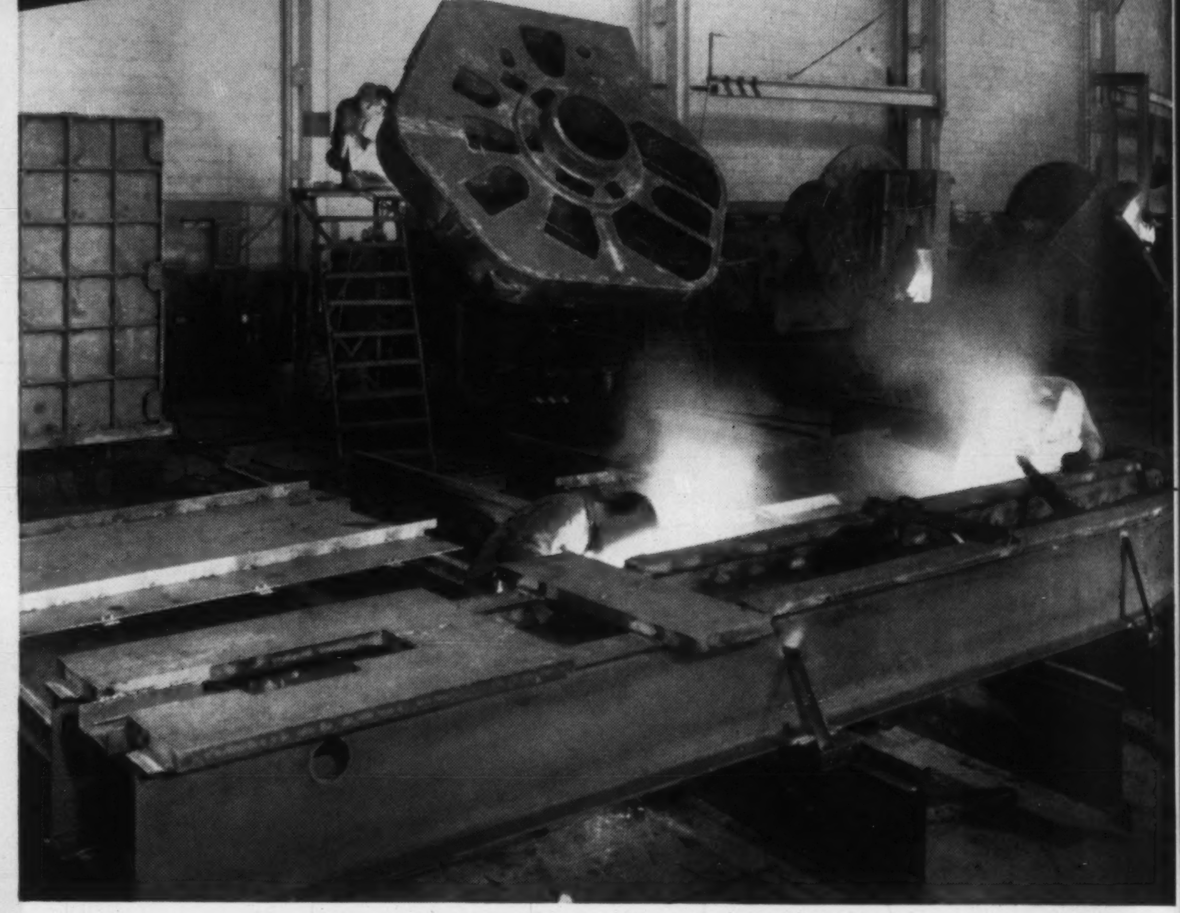

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Materials Engineering in Product Design & Manufacture

Materials & Methods®

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A splicing chamber in downtown Manhattan, New York City. At high tides these cables are submerged in heavily polluted, corrosive river water. The cable racks and supports, and the ladder are Monel. This ladder was installed 16 years ago and is as good as new. The supports were installed 13 years ago and are standing up just as well.

16 years in a manhole
...yet Monel shows no sign of corrosion

You're looking into a splicing chamber, looking down from a New York City Street.

The air down there is damp, corrosive. And at high tides polluted harbor water creeps up underground ducts, covers the cables that connect the city's nearly 4 million phones, its telegraph lines, its vital police and fire alarm systems.

It covers the cable supports, the cable support racks, even much of the ladder you see.

All these fixtures were once made of steel. But they deteriorated so rapidly under these severely corrosive conditions, that they had to be replaced in two or three years.

So Monel came into the picture.

In *this* manhole it has been down there 16 years. In others much longer — the oldest Monel ladder was installed in 1918. And in all that time this customer has *never had to replace any Monel equipment because of failure due to corrosion.*

That's something to think about!

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Materials Outlook

PRICES OF COPPER, BRASS AND MAGNESIUM mill products have been increased. Magnesium mill products are up two to four cents per pound. Base price for copper is 43 (up seven cents per pound) and, with the continuing shortage of the metal and high foreign prices, there is a good chance that it will rise still more before too long.

METAL FIBER PARTS made by felting, pressing and sintering metal fibers have been produced in thicknesses ranging from 0.010 to 1 in., in porosities as high as 98%, and with strengths as high as 35,000 psi. These radically new materials, now under development, are tougher and have higher strength-porosity ratios than powder metal parts. They may prove particularly useful in toughening brittle cermets.*

THE LARGEST RIGID PLASTICS STRUCTURE ever built was experimentally assembled a few weeks ago. The truncated clear-span sphere is 55 ft in dia, stands about 40 ft high, and consists essentially of polyester-glass equilateral triangles bolted together and made weathertight with rubber gasketing. The "Geodesic" structure, designed by Buckminster Fuller as the dome for an Arctic radar warning station, weighs only six tons.

A NEW FAMILY OF ELECTRICAL INSULATING MATERIALS based on acrylic resins is emerging from DuPont's laboratories. A wire enamel has already undergone extensive field trials. A 3-mil resin-coated glass fabric and laminates of various thicknesses are also available. These materials have good chemical resistance and are claimed to withstand temperatures above 266 F (Class B minimum) for extended periods and intermittent temperatures up to 300 F. . . . AN IMPROVED SILICONE VARNISH for Class H electrical insulation has been developed. It is much tougher at elevated temperatures than its silicone predecessors. It is also said to cure as rapidly at 300 F as others do at 480 F and can therefore be used on Class B equipment, making possible continuous operation at hottest spot temperatures at least 50 F above normal limits for Class B materials.

NODULAR OR DUCTILE IRON CAN BE READILY FLAME-HARDENED, a recent study shows. Techniques are similar to those used for steels of medium hardenability. Hardness of 50-55 R_C can be obtained by self quenching of predominantly ferritic irons, 53-58 R_C by water quenching of pearlitic irons, and 56-62 R_C by water quenching of pearlitic irons.*

A HIGHLY CORROSION-RESISTANT ZIRCONIUM ALLOY has been developed by Westinghouse. Its corrosion rate in the extremely corrosive hot pressurized water system of a nuclear reactor is only a few ten-thousandths of an inch per year. It consists of zirconium made by the Kroll process and refined by the iodide vapor deposi-

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* Watch forthcoming issues of M&M for more details.

Materials Outlook

tion process, plus low-neutron-absorption additions of 1.5 tin, 0.12 iron, 0.10 chromium and 0.05% nickel. . . . UNUSUALLY DENSE CONCRETE based on a ferrophosphorus aggregate makes possible thinner walls for nuclear "hot cells". The new material weighs about 300 lb per cu ft—about twice as much as ordinary concrete. . . . GRAPHITE UNDERGOES MARKED CHANGES when irradiated under certain conditions. According to a GE paper, it may expand in volume, double in strength, and decrease 50-fold in thermal conductivity, but these effects can be reduced by manufacturing techniques and by increasing temperature of the graphite in the reactor.

AN "ALL-ALUMINUM" 2½-TON TRUCK, developed by Chrysler for Army airborne operations, weighs only 9000 lb—about 40% less than conventional models. It has aluminum wheels, axles and body. . . . Aluminum permanent mold castings of up to 780 lb are being made. . . . SUPER-PURITY ALUMINUM, until now mostly obtained abroad, is now being made by Kaiser Aluminum in pig (99.99%) and foil (99.97%).

COSTLY NYLON PAPER has been produced for the first time. It is said to be almost impossible to tear by hand, highly resistant to chemical attack, moisture-resistant, and resistant to molds, bacteria and light. Possible applications are bags, filters, maps and vital documents. . . . A sized cellulosic paper that is air-permeable but impermeable to liquids is being marketed. . . . GLASS FLAKE PAPER is being studied. Though similar in construction to mica paper, it would be transparent and colorless instead of silvery and metallic in appearance. Like recently-developed glass and asbestos fiber papers, it is considered a possible base for high-temperature reinforced plastic laminates.

RUBBER "EXTRUDED" SHAPES THAT ARE NOT EXTRUSIONS are being made by a new continuous molding process developed by U.S. Rubber. Parts are continuous and have the uniform cross sections characteristic of extrusions, but they are molded and vulcanized under pressure; consequently, closer tolerances (equivalent to those of press-molded parts) can be held and softer rubbers may be used. . . . STRONGER O-RINGS are being made by a new molding process which eliminates flash and also eliminates the time lag between application of heat (start of vulcanization) and application of pressure. The process utilizes multiple-cavity "cookie cutter" dies which cut out the right amount of material from rubber sheet as they close.*

INORGANIC FIBER-REINFORCED TEFLON SHEET is being used in the manufacture of flat gaskets and machined parts where resistance to heat distortion, cold flow and extrusion are desired in addition to the inherent heat and chemical resistance of Teflon, and where lower electrical and dry lubricating properties can be tolerated.*

* Watch forthcoming issues of M&M for more details.

Materials BRIEFS

Pneumatic Bricks
Triangular plastics pillows about 3 ft long and 4 in. thick, air inflated to about 2 psi have been developed by the Air Force and Armour Research for building air-tight domes. Pillows have walls only a few mils thick.

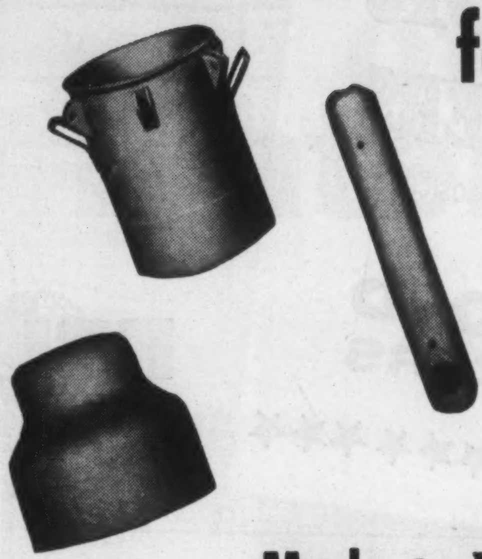
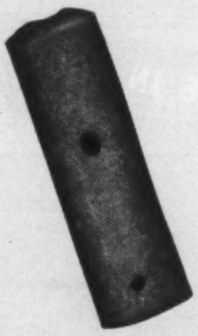
Ears Have It
The sound of metal grinding does more than bother neighbors, according to recent research at U. of Michigan. High frequency vibrations induced by grinding reduce temperatures in ground surfaces, reduce the incidence of thermal cracks, and minimize the effects of hardness variations.

Silt Sleuth
Movements of river silt and mud can be traced by the use of radioactive ground glass.

Rubber Odors
Rubber will pick up and retain odors when stored between compounding and processing. Common practice of allowing relaxation time after compounding is a potential source of contaminant odor.

Filter Board
A wood fiber board impregnated with chemicals provides an effective filter against atomic dusts, poison gas, and germ warfare, according to the Dept. of Agriculture. Board resembles ordinary building fiber-board, can be used to line shelters.

Mass Glass
A glass fiber producer is sending a display of glass fiber products around the country in an air conditioned glass fiber truck trailer insulated with glass fiber and lined with glass fiber acoustic panels.

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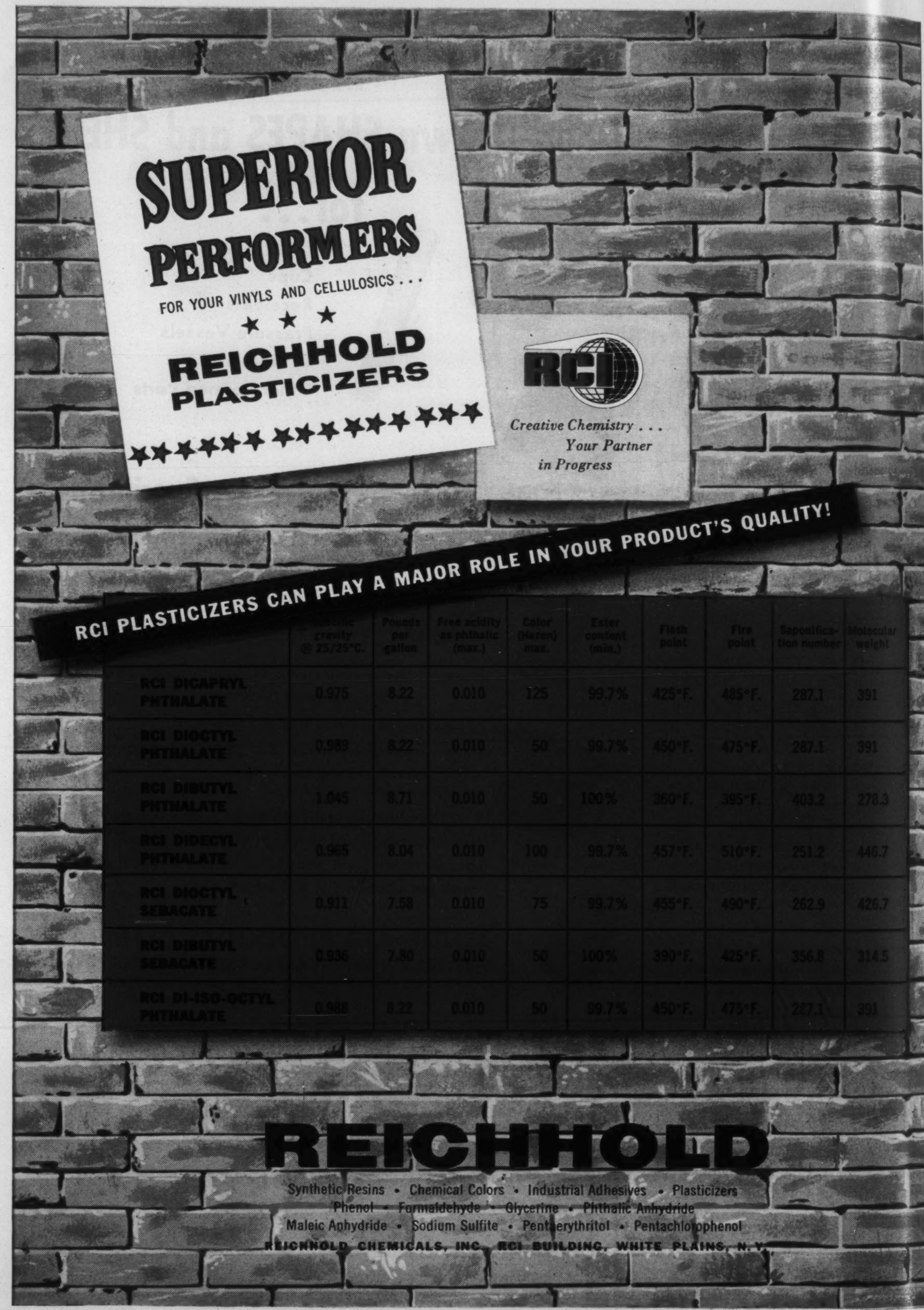

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RCI DIOCTYL SEBACATE	0.911	7.58	0.010	75	99.7%	455°F.	490°F.	262.9	426.7
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Men of Materials...

Dr. Sidney Marsh Cadwell, director of research and development of United States Rubber Company, has contributed greatly to the technology of rubber. His 65 patents include the development of antioxidants which have improved the performance of many rubber products. His name appears on most golf balls—with the scuff-resistant Cadwell cover. He was first to promote use of rayon cord GR-S truck tires, making them good enough for commercial and military use during WW II. He was also among the original proponents of the use of butyl rubber for inner tubes.

Cadwell says . . .

Research will provide better tires, improved rubber goods . . .

"Few industries have been offered as many new materials in the last decade as the rubber products industries. In automotive tires alone, the effect of new materials has been pronounced. Natural rubber has given way to many types of synthetics, so that today about 50% of the rubber used in passenger car tires is man-made. Such new materials now used in so many rubber products are the direct result of highly organized, continous research.

"The research goal of the US Rubber Company is better products. In rubber, better materials begin in the high polymer research laboratories. However, new monomers, polymers, and copolymers are not end products—research laboratories must evaluate and integrate the new basic materials in the light of production and final product requirements.

"The recent sale of government owned research plants to private industry is providing great impetus to the development of improved rubbers. During its tenure of ownership, the Government sponsored excellent basic research, much of which has yet to be evaluated in terms of the marketplace. In purchasing the Port Neches, Texas, GR-S plant, the Texas Company and the US Rubber Company have formed a joint subsidiary—the Texas-US Chemical Company—which exemplifies the common interest of the two industries in high polymer techniques. Today, both oil and rubber industries are engaged in basic high polymer research, and are carrying it through toward final products in their respective fields.

"Progress in rubber technology over the last forty-two years—the time that has elapsed since US Rubber's Central Research facility moved into its own building—is difficult to measure. Tires, thanks to research, now run five times as far at higher speeds, yet cost less. The not distant future holds promise of tires with five times the lifetime of today's, with 100 times the safety factor. The new materials in these tires may be all synthetic, or may be based on natural rubbers. The research laboratories will continue to search for new basic materials and to add constant improvements to established rubbers. The success we have had in the past, we can be sure, will continue."

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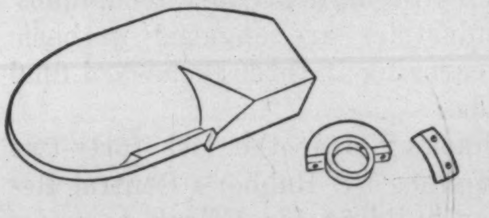

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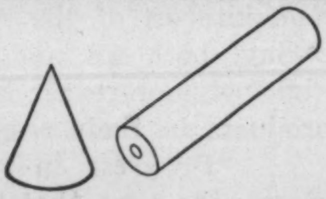
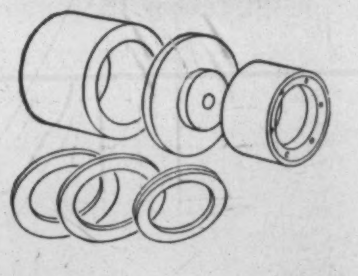


STABLE ROTORS



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MATERIALS ENGINEERING News Digest

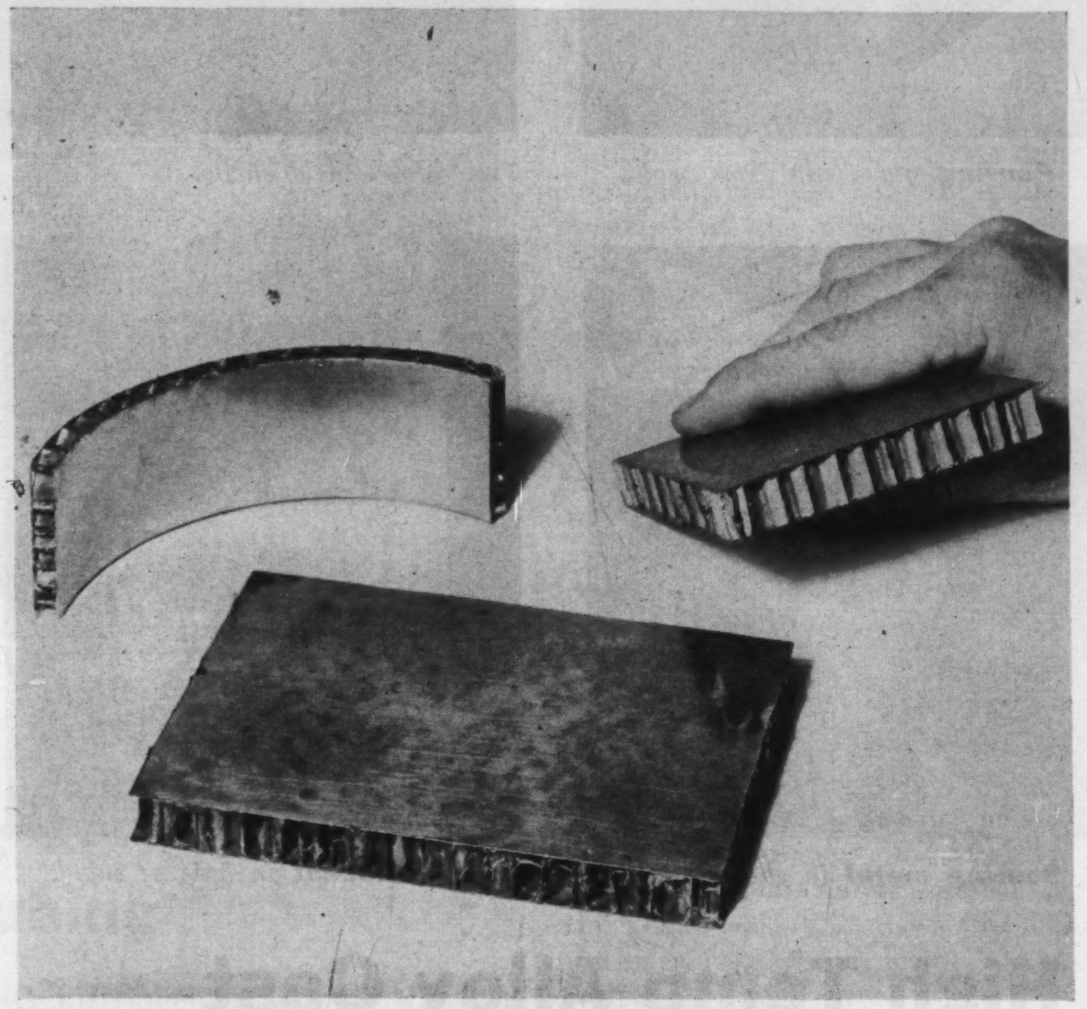
Synthetic Rubber Production Up

The United States synthetic rubber producing industry, in its first two months of private ownership and operation, turned out rubber at a rate comparable with the highest level in the industry's history, according to William I. Burt, President, Goodrich-Gulf Chemicals, Inc. Goodrich - Gulf owns and operates a 90,000 ton a year synthetic rubber plant and a large butadiene plant at Port Neches, Texas, and is a jointly owned company of the Gulf Oil Corp. and The B. F. Goodrich Co.

"Private owners purchased the GR-S, or general purpose, synthetic rubber plants late in April, 1955. During May and June, the first two months under private ownership, the entire United States synthetic rubber industry turned out about 160,300 long tons of synthetics, of which approximately 130,700 long tons was GR-S, the general purpose tire type rubber," Burt said.

"This record level of production, 73% higher than May and June, 1954, was reached in spite of the fact that the Institute, W. Va., plant, rated at 122,000 long tons of annual capacity, is in idle standby. The only two months' period of man-made rubber production surpassing that of May-June 1955, was during the Korean war, when total U.S. synthetic production reached 168,-254 long tons.

"Synthetic rubber plants are now supplying 60% of America's total new rubber needs with natural rubber accounting for only 40%. Elimination of bottlenecks and the additons to production capacity now underway, or planned at the synthetic rubber plants, will assure American, as well as foreign rubber products manufacturers, of ample supplies of constantly improved rubber."



Vacuum brazed *titanium sandwich structures.*

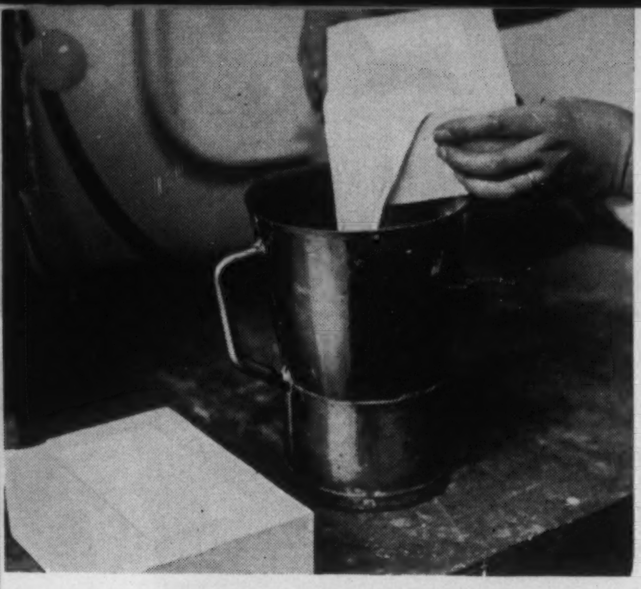
Fluxless Vacuum Brazing Joins Titanium Sandwiches

A vacuum brazing technique for titanium has overcome many of the difficulties associated with joining parts made of the heat- and oxygen-sensitive metal. Under high vacuum, silver or silver manganese brazing alloy without flux will join titanium parts at lower than normal brazing temperatures. Wall Colmonoy Corp., developers of the process, report that brazed titanium assemblies show no embrittlement and a minimum of distortion. The process is now undergoing tests on titanium honeycomb structures and turbine blades.

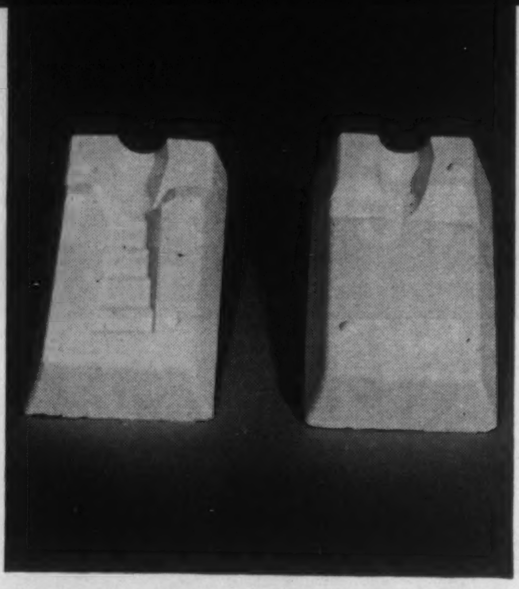
Since the process requires no flux, it permits the simultaneous performance of multiple brazing operations. The wetting and flow characteristics of the brazing alloy under vacuum conditions are adequate to ensure complete brazing of all joints, regardless of contour of position. Components can be assembled prior to the application of the brazing alloy.

How it works

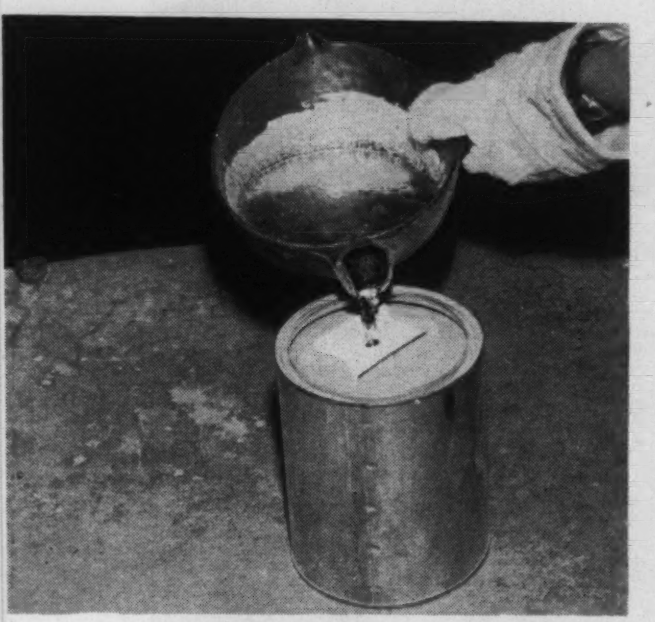
The honeycomb sandwiches in the illustration were assembled with brazing alloy shim strips between the core and the face sheets. Weighted and placed in a vacuum retort, the assembly was heated to brazing temperature. The process will join titanium and titanium-alloy assemblies, and dissimilar metals, such as stainless steel and titanium. The size is limited only by the vacuum retort dimensions.



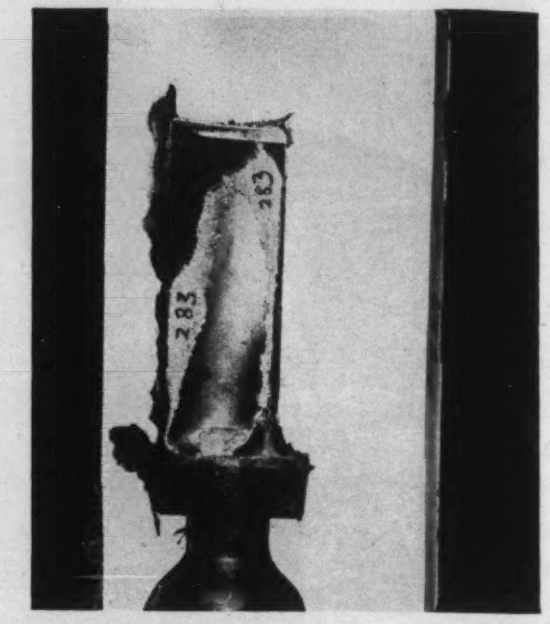
Pouring *glass slip from mold.*



Two glass *mold shells.*



Pouring metal *in shell mold.*



Turbine bucket *in half of mold.*

High Temp Alloy Cast In Glass Powder Molds

Glass molds for precision shell casting have reduced rejects to 10% or less in test runs by the developers of the process, Corning Glass Works. The Glascast process, designed specially for work with high temperature alloys, provides the tight dimensional control and surface finish comparable to investment casting. The molds will withstand extreme temperatures, permitting close regulation of metallurgical structure and reproduction of fine design detail.

In test production of jet engine buckets and vanes, 90% of finished castings met precision standards on surface finish. The Glascast process, because it eliminates the precoat step used in investment casting and is not subject to cracking and spalling, cuts down the number of rejects considerably.

How it works

The mold material for glass casting is a slurry of silica glass particles suspended in water. To make a mold, the slurry is poured over a porous plaster form, allowed to stand until enough water is absorbed to build up a shell of glass solids over the form. The shell is then dried at about 200 F, removed from the form, fired for ½ hr at 1740 to 1920 F. The glass mold is then ready for casting or storage. The casting process itself is similar to shell molding. The glass molds are wired or taped together and backed by loose sand, shot or refractory material. The mold should be preheated to near casting temperature.

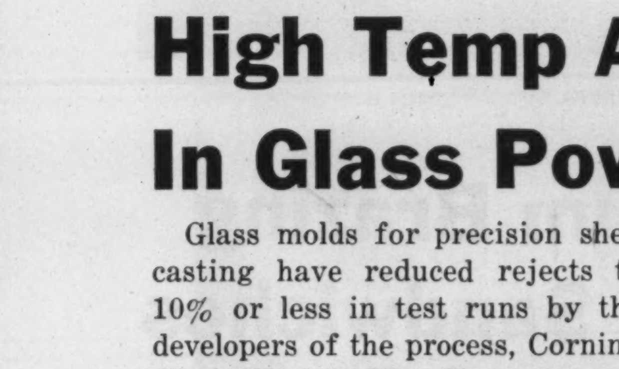
The Glascast technique has been under development for three years by the Corning Glass Works with the assistance of Massachusetts Institute of Technology, the Engineered Precision Casting Co., and others. After passing tests in commercial production situations, the process has been deemed suitable for general release.

Casting properties

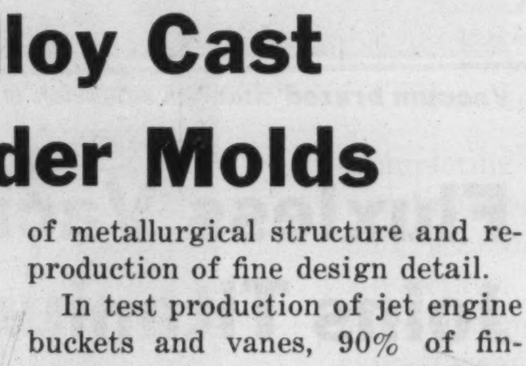
Castings produced by the glass mold process have blemish-free surfaces of better than 40 micro-in. finish, according to Corning. The castings thus require a minimum of further conditioning. The mold material, silica glass, has high chemical stability, and does not react with the cast metal or its oxides to cause surface imperfections or blow holes. Accurate control of grain size is possible, since metal pouring temperatures can be as high as 3200 F. The vitreous mold material has very low thermal expansion, and does not undergo abrupt volumetric changes typical of foundry sands. Tolerances of plus or minus 0.005 in. per in. are not difficult to obtain, according to the results of testing runs. The glass mold material has high resistance to thermal shock. There is little danger of cracking during firing or molding.

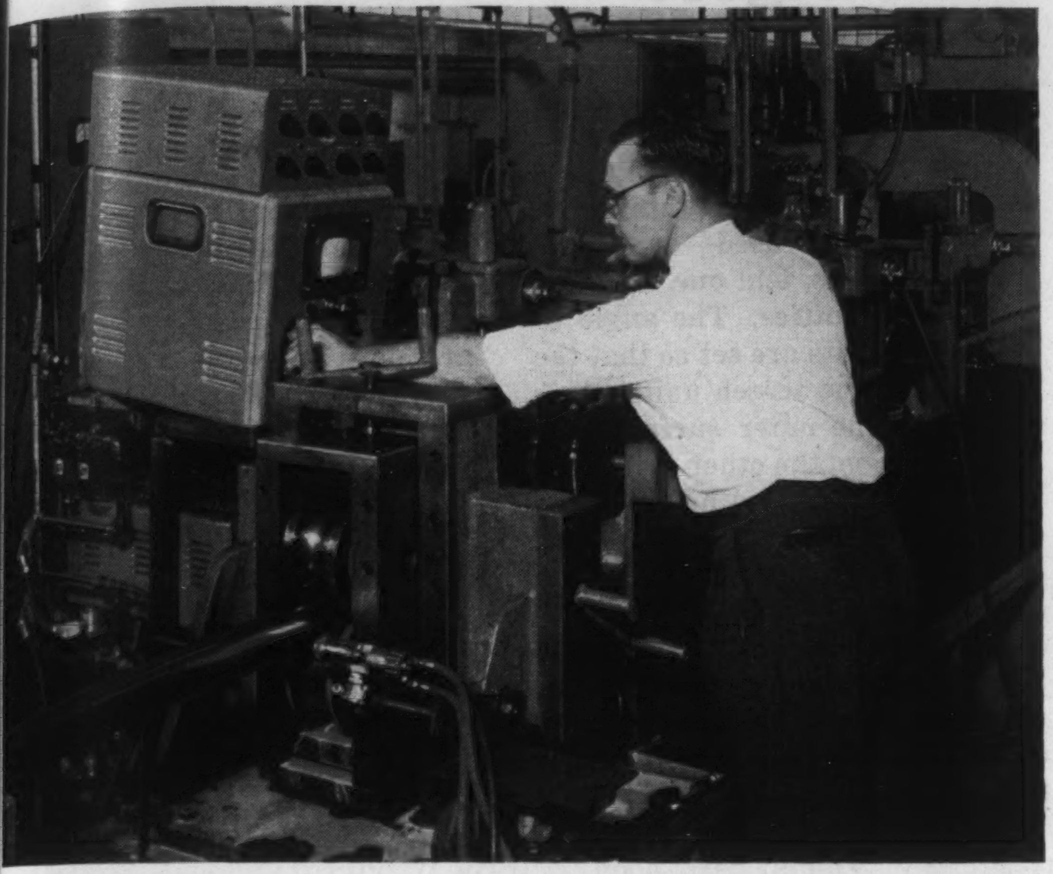
A finished plaster mold form will make from 10 to 15 shells before surface and dimensional deterioration sets in. The slurry will last indefinitely under constant agitation.

As cast buckets *from glascast molds.*



Sand blasted *as cast turbine bucket.*





***Ultrasonic test unit** on final rolls tests tubing at production speeds.*

Symposium reports progress in . . .

Ultrasonic Testing of Small Diameter Tubing

Increased demand for 100% tested, small-diameter tubing for boiler and atomic energy applications has sparked development of ultrasonic test methods for inspecting tubing as it comes off the production rolls. Tubing manufacturers, in cooperation with producers of ultrasonic testing equipment, have devised satisfactory methods for testing tubing down to 1 in. in diameter. Although smaller tubing has been tested successfully, most tube makers feel that there is plenty of room for improvement in techniques, and a definite need for more realistic standards in the whole field of tube testing.

Last month, the Sperry Corp. invited representatives of industry, government, and private research foundations to a symposium on ultrasonic testing of small diameter tubing. Sperry spokesmen told the conferees that the purpose of the meeting was to close the gap between what Sperry knew about its instruments, and the way its customers were using them.

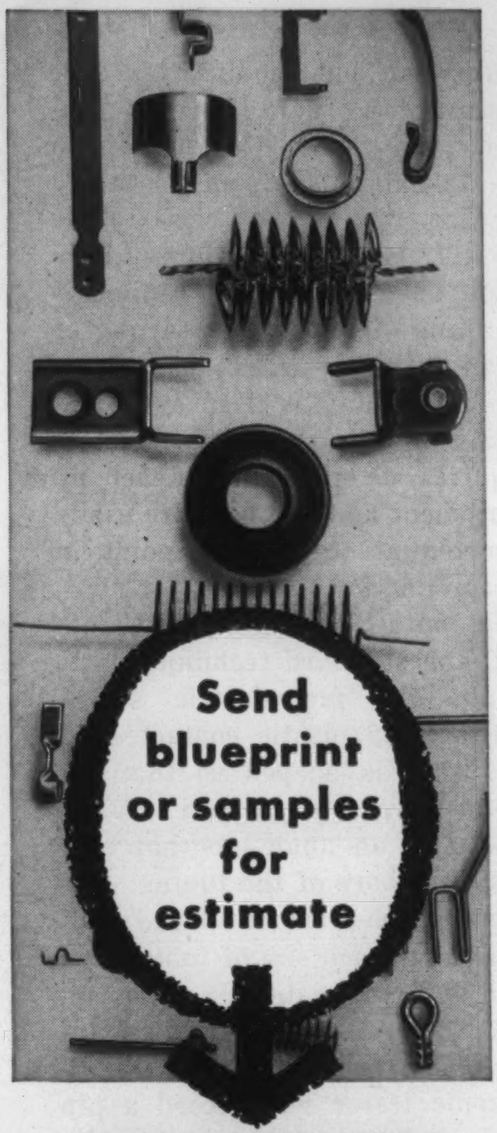
Equally important was a discussion of standards for ultrasonic testing. A Sperry spokesman told the audience, "When it comes to standards, we have to be a kind of referee on the sidelines. We can't set standards, but we can tell you what our instruments will do and what their capabilities are. We have had some experience with unrealistic standards—where the tolerances were so high that suppliers could not make the tubing, and the standards were set up as a result of ultrasonic testing. Because we invented the ultrasonics, so to speak, we had to go in and settle the hash. We must face standards in a realistic way so they are tight enough to give you the products you need, yet loose enough to allow reasonable production. We must realize that the production men have problems, too."

Testing small diameter tubing does not require radically new test equipment, but modifications are necessary in order to prevent transient and reflected signals from the initial pulse from obscuring signals from defects close to the testing head. Techniques have been developed for both immersion and direct contact testing of small diameter tubes, but direct contact testing is used by a majority of tube producers, since it requires a minimum of set up equipment and can be more easily inserted at the proper point in the production line.

In contact testing pipe and tubing, the standard technique is to mount the piezoelectric search crystal in a plastic contact shoe. The shoe is shaped so that the sound waves are directed into the tubing at an angle, so that they graze the bore of the tubing. The contact shoe must be shaped individually to each size of tubing and each different material to compensate for different refraction indices. Properly arranged, the ultrasonic tester will record a pip for initial contact, a pip when the beam encounters any discontinuity in the solid material or a defect in the i.d. or o.d. face, and a pip for the back reflection from the inner wall of the tube bore.

The technique described above is satisfactory for large, thick walled tubing, in cases where tiny defects on a portion of the outside of the pipe are not vital. With small diameter tubing, such defects are much more important, and must be detected. To minimize initial pulse reflection at the interface of the tubing search unit, specially shaped plastic wedges are used to trap extraneous reflections and attenuate the interface pulse. General Electric has developed a "J" shaped wedge containing the crystal in the short leg that is so arranged that the unwanted reflected waves are trapped in the long stem. Sperry has worked out a long, shoe-shaped wedge which narrows the search beam and attenuates spurious reflections.

Immersion testing, which uses a liquid, usually water, as a couplant, has the advantage of more flexible search units. Since no rigid connection between the crys-



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News Digest

tal and test piece is necessary, the angle of the search units in regard to the tubing can be changed at will. For testing tubing, two search units are used—one to detect i.d. defects, and one to detect o.d. discontinuities. The angle of the search units are set so that the beam from one search unit is tangential to the outer surface, and the beam from the other is tangential to the bore. Varying the water column and position of the search units makes it simpler to weed out spurious reflections. Since it is necessary to run tubing through the water bath, immersion testing units require considerably more equipment than the contact testers.

Standards

Sperry's John Smack, who is also chairman of the Ultrasonic Committee of the ASTM, pointed out to the symposium the need for the development of ultrasonic tube-testing standards. In reviewing current activities, he outlined two recommended practices now up for presentation to the ASTM for approval. The *Tentative Recommended Standard for Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves Introduced by Direct Contact*, is only a beginning, Smack said. Project committees are now being organized to investigate angle inspection, weld inspection, reference blocks, immersion testing, and the compilation of a glossary of ultrasonic terminology. The other

(Continued on p. 234)

Letters

Rolled Copper Foil

Sirs:

Our Chief Technical Advisor had a comment to make on your article entitled, "Materials for Printed Circuits" (July '55). On page 96 you stated that "electrodeposited copper foil is the only copper material available in 36 in. widths at present." For your information, Revere makes rolled copper [foil] up to 38 in. wide, and it is particularly adapted to fine line [printed circuits] because of its uniformity and density. We thought that this information might be of interest to you.

With best wishes,
Donald F. Haggerty
Revere Copper and Brass, Inc.

With apologies to Revere for the oversight, M&M is glad to pass on the information that 38 in. wide, rolled copper strip is available now in 1-oz and 2-oz weights (0.0015 in. and 0.0027 in. thick, respectively).

To the editor:

We feel that the MATERIALS & METHODS Manual No. 114 (March, '55), *Short Run Press Formed Parts*, is on the whole a comprehensive and useful summary of the subject. We would like to correct one particular statement made concerning our process of Marforming, and to offer some additional information in respect to it.

The manual states that the Hydroform process has an advantage over the Marform process in that sharpening or edging of external radii can be accomplished during the draw operation by a slight retraction of the hydroform punch. We would like to point out that this advantage is shared by the Marform process, since the same result is accomplished in Marforming by advancing the cushion ram at the appropriate point in the draw. This procedure lifts the blankholder plate a small amount relative to the stationary punch and produces a sharp radius. It is performed easily and quickly by the injection of a small amount of oil into the cushion cylinder from the high pressure pumping equipment of the hydraulic system.

We would also like to point out, relative to the pressure limitations mentioned in the manual, that the Marform process has been extended to 15,000 psi incorporated in a recent installation at Bridgeport, Conn. Still higher pad pressures are possible, if desired, by substitution of smaller diameter rubber pads in the same press.

S. L. Morrison
Hydropress, Inc.

One point of view

A salute to a big forward step

Many voices have been raised, including ours, during recent years demanding that more research be done on engineering materials. There is general agreement that progress in many fields is limited because we do not have the proper materials to meet the demands of advanced designs.

It is heartening to note that certain segments of industry are facing up to this problem and, what is more important, doing something about it. One gigantic step forward has been taken by General Electric, which recently dedicated the Metals and Ceramics Building as an addition to its Research Laboratories. Although all of the usual apparatus of a research laboratory is available, the new building is equipped more like a good-sized factory. The reason for this is that GE feels that much must be done before a laboratory development can be translated into a full-scale operation. This new facility also differs from many industry research operations in that most of the work will be of a fundamental nature rather than concerned with solving specific problems.

In discussing the objectives of the new building, Dr. J. H. Holloman, Director of GE's Metallurgy and Ceramics Research Department, listed these as the most important:

"To ascertain and analyze the areas of most critical need for materials and processes.

"To develop new processes for new businesses.

"To develop new materials to improve products.

"To study existing materials and obtain a better understanding of their properties and processing.

"To operate pilot plants and obtain economic data."

Although the new laboratory is intended to help General Electric specifically, it is almost certain that knowledge obtained there will help all of industry because its scientists are encouraged to write about their findings.

We congratulate General Electric and its research leaders for having the foresight to plan such a laboratory operation as this, and are more than pleased to cite them again for determining to share their findings with others.

T. C. Du Mond

		GROUP 1					
Ask these 4 questions to determine the steel group		C-1018	C-1212 B-1112	C-1213 B-1113	Ledloy	C-1117	4615
1. Is part to be case-hardened?		Yes	Yes	Yes	Yes	Yes	Yes
2. Is part to be through-hardened?							
3. Is it practical or advantageous to make part from pre-hardened bar stock?							
4. Can part be made directly from hot or cold-rolled stock?		ok	ok	ok	ok	ok	
Ask these 6 questions to select the individual steel from the group:							
5. What hardness[4] and/or strength required?	a. Core	C20	C12	C12	C12	C20	C30
	b. Surface	C64	C62	C62	C62	C64	C64
6. What is largest cross-section of part, in.?		¾	½	½	½	¾	1½
7. Is induction or flame hardening required?						?	?
8. Is welding required to fabricate part?		ok				?	ok
9. What machinability is required?		55	100	130	160	90	55
10. What is cost factor of steel?	a. Hot Rolled	0.78	—	—	—	0.88	1.26
	b. Cold Finished	0.95	1.00	1.02	1.12	0.97	1.51

TABLE 1

[1] *annealed*
[2] *heat treated before nitriding*
[3] *heat treated*
[4] *Rockwell*
[5] *% of B-1112*

Answers to 10 Questions Help You

■ This article outlines a method that has proved successful in selecting the proper steel for most applications. The method assumes that there is one or perhaps two grades of steel best suited to a particular application from the point of view of ease of production and over-all economy. It also assumes knowledge of the required strength of the part, the heat-treating procedure and a familiarity with the manner of fabrication. Steels discussed are the engineering steels most used for machine parts and maintenance purposes where heat or corrosion resistance is not required.

In selecting a steel for a particular task, many variables must be considered. The ideal type can be defined as that which will perform the task satisfactorily and do so at lowest cost to the manufacturer in material outlay and fabrication or assembly.

Ten factors usually form the bases in selecting a given steel for any end use. These factors by no means cover the range of possible variables, but they are the most frequently recurring and most important ones. Using these factors, any designer or engineer can select by a process of elimination the one or two grades best suited to the purpose he has in mind.

Now let us consider 10 questions based on the factors mentioned. First, questions 1 through 4 are asked to determine in what group the steel most suitable for your application will be found. Second, questions 5 through 10 are asked to pick the right steel from within the group.

SELECTING THE STEEL GROUP

1 *Is the part to be case hardened?*

If the answer is, yes, the proper steels will be found in Group 1, since all of these steels can be case hardened, although the screw

				GROUP 2										GROUP 3			
4620	8620	E-3310[1]	Nitralloy 135 Modified[2]	E-4130[1] Aircraft Quality	E-8630[1] Aircraft Quality	C-1045	C-1141	8740[1] 8640[1]	4140[1]	E-4340[1] Aircraft Quality	4150[1]	4150[1] Modified	E-6150[1]	C-1144 Strain Tempered	4140[3]	4340[3]	4150 Modified[3]
Yes	Yes	Yes	Yes														
				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
			Yes											Yes	Yes	Yes	Yes
						ok	ok							ok			
C35	C35	45	C40	C48	C48	C48	C48	C54	C54	C55	C60	C60	C60	C23	C28	C28	C34
C64	C64	62	C72	C52	C52	C60	C58	C58	C58	C60	C62	C62	C62	C62	C60	C60	C62
1¾	1¾	3½	4	2¾	2¾	2	2¼	3¾	4½	6½	5½	5½	5	3	4¾	6½	5½
?	?	?		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok
ok	ok			ok	ok												
52	50	35	35	67	65	55	70	60	60	50	55	70	55	70	45	40	65
1.25	1.25	1.71	2.00	—	—	0.84	0.91	1.28	1.12	1.75	1.23	1.27	1.66	—	1.47	1.71	1.67
1.49	1.37	—	2.28	1.81	1.84	0.95	1.00	1.71	1.63	2.05	1.63	1.69	—	1.23	1.84	—	1.91

Pick the Right Steel

by J. J. Hauptly, *Joseph T. Ryerson & Son, Inc.*

stocks are not normally recommended for such treatment.

A steel is case hardened when a Rockwell hardness of approximately C60 or higher is required to resist high rates of wear in service. The term *case hardening* implies all methods of carburizing, nitriding or any combination of the two. Properly case hardened steel is a duplex steel with a very hard case and a softer core. If a high hardness is desirable throughout the cross-section of the part, the application demands a through-hardening steel.

The maximum hardness obtained by carburizing is a function of the final carbon content of the case, the section size of the part and the severity of the quench. The latter is determined by the quenching medium, such as oil or water. The surface hardness value shown in Table 1 in line 5b can be called the *practical maximum.*

2 *Is the part to be through-hardened?*

If the answer is, yes, the proper steels will be found in Group 2, which includes carbon and alloy steels of medium carbon content.

3 *Would it be practical or advantageous to make this part from preheat treated bar stock?*

Although a general answer to this question is impossible without knowing the type and extent of machining operations involved, suitable steels will be found in Group 3.

4 *Can the part be made directly from hot or cold rolled stock?*

If the answer is yes to this question, suitable steels can be found in all three groups.

Any material selected for a part that is not to be heat treated must depend on its strength in the as rolled or drawn condition. Strength depends on the chemistry of the steel, the cooling rate after rolling, the section size and, in the case of cold drawn bars, the amount of cold reduction given to the stock during this operation. Cold drawing increases the tensile strength and yield point and lowers the ductility. Properties of as-rolled steels drop off rather sharply as section size increases. The strength which is calculated for small sizes is not always applicable to larger sizes because of this effect.

The usual limit for cold drawn bars is 2 15/16 in. Bars above this size are turned and polished from hot rolled bars and have mechanical properties similar to those of a hot rolled bar of the same analysis.

SELECTING STEEL FROM GROUP 1

5a *What core strength is required?*

The practical maximum core hardnesses of the case-hardening grades are shown also in Table 1.

In a part where stresses on the core area are low, core strength is a minor consideration and any of the carbon steels should be satisfactory. As strength requirements of the core increase we must proceed to the richer alloys until we reach E-3310 which yields a practical maximum core hardness of C-45.

The equipment designer knows the core stresses involved and has calculated the required core strength. This is readily convertible to hardness values by referring to Table 2. Assuming the required minimum core strength of the part is 130,000 psi, Table 2 indicates that a minimum core hardness of C-28 is necessary. A check of line 5a, Table 1, shows that 4615 is the first steel meeting this requirement.

5b *What surface hardness is required?*

The practical maximum surface hardness for all of the steels in Group 1 is shown in Table 1. There is little difference in the group excepting for Nitralloy-135 Modified. When nitrided in an atmosphere of ammonia gas, this steel has a surface hardness of about Rockwell C-70 and resists softening up to about 1000 F. If these properties are suitable it makes an ideal selection. One precaution is necessary, however. Sharp corners and edges must be broken when using this grade to prevent chipping during assembly or use. Thus Nitralloy-135 Modified would not be suitable for blades or knives and similar applications. Of the remaining steels in Group 1, the alloy steels will show more resistance to softening at elevated temperatures than the carbon steels.

Case hardened spline shaft, *perhaps 18 in. long, has a maximum cross-section at the base of splines of 1¾ in. and various diameters at bearing areas and journals. Two bearing areas adjacent to splines act as inner race for needle bearings and must be Rockwell C-60 or higher. Part is made from carburized C-1117 because of large output. Distortion is a major factor because excessive warpage in heat treatment may not be removed by grinding. Alternately, grinding may produce an uneven case depth or completely remove the case.*

Carburizing alloy steel such as 4615, 4620, or 8620 might be preferable to C-1117 because these steels can be oil quenched to obtain Rc 60/62 giving less distortion and higher core strength. A leaded 8620 would have solved the question of machinability. Neither Nitralloy nor E-3310 would be needed or desirable from a standpoint of cost, machinability or required core strength.

6 *What is the largest cross-section of the part?*

Hardenability, the property which determines the depth of hardening on quenching is one of the most important factors in the selection of steel. As alloy content increases so does hardenability but not necessarily in proportion. Some alloying elements have a more pronounced effect than others and can be added in smaller quantities to produce a hardenability equivalent to relatively large quantities of other elements.

The more common alloying elements added to steel in the order of their decreasing effect on hardenability are: manganese, molybdenum, chromium, silicon and nickel. Vanadium has a positive effect on hardenability in small quantities but has an adverse effect in larger amounts.

Line 6 indicates the practical maximum diameter for 4615 is 1½ in., for 4620, it is 1¾ in., etc. This does not mean that 4615, or 4620 cannot be used in larger sections, it merely indicates that in such sections there will be a lower hardness at the center than in the core area immediately beneath the case. Frequently, parts made from large diameter bars are much smaller in length or face than they are in diameter. Any boring of the center will further reduce the largest cross-section, thus minimizing the hardenability factor.

As an example of the application of hardenability assume that a large driven roller requires a surface hardness of C-60 or higher and a core strength of 145,000 psi. Table 2 shows that a minimum core hardness of C-32 is necessary. If the roller were 2 in. in diameter, either type 4620 or 8620 would be satisfactory, but if it were 6 in. in diameter, E-3310 should be used. Selection should be based on using a type good enough for the job but not necessarily with the highest hardenability. Reasons will be more apparent in discussing relative machinability and cost.

7 *Is induction or flame hardening to be used?*

All steels in Group 1 excepting Nitralloy are intended for carburizing, quenching in oil or water and tempering. However, the combination of carburizing, cooling slowly, removing certain areas of the case by machining, and finally induction or flame hardening is being used with increasing frequency. A treatment of this nature would be used to minimize distortion and to harden selectively. Grades with a question mark can be handled in this way. The screw stocks would not be too satisfactory for this procedure.

Nitralloy is nitrided in ammonia gas and is never induction or flame hardened.

TABLE 2—MECHANICAL PROPERTIES IN RELATION TO HARDNESS

These approximate relationships are based on hardness and apply only to fully quenched or fully quenched and tempered steels. This table will be more accurate for alloys of 0.30% carbon or higher, because steels with less than 0.30% carbon usually have yield point values lower than those shown.

Rockwell "C" Hardness	Brinell Hardness	Tensile Strength, psi	Yield Point, psi	Elong in 2 in.	% Red of Area
14	197	93,000–103,000	69,000–78,000	22–28	60–68
16	207	98,000–108,000	73,000–84,000	21.5–27.5	59–67
18	217	103,000–114,000	76,000–90,000	21–27.5	58–66
20	223	106,000–117,000	79,000–93,000	20.5–26.3	57.5–65.5
22	235	112,000–124,000	85,000–99,000	20–25.5	56.5–64.5
24	248	118,000–131,000	92,000–107,000	19.5–24.5	55–63
26	262	124,000–138,000	99,000–114,000	18.5–24	54–61.5
28	277	131,000–146,000	107,000–122,000	18–22.5	52–60
30	293	138,000–154,000	116,000–131,000	17–22	51–59
32	311	146,000–164,000	125,000–141,000	16–20.5	49–57
34	321	151,000–170,000	131,000–146,000	15.5–20	48–56
36	341	160,000–180,000	141,000–157,000	14.5–18.5	46–54
38	363	171,000–193,000	153,000–170,000	13.5–17	43.5–51.5
40	379	178,000–201,000	163,000–179,000	12.5–16	42–50
42	401	188,000–222,000	176,000–185,000	11–15	40–49

8 *Is welding required to fabricate the part?*

When welding is necessary to fabricate or assemble a part, the carbon content should be less than 0.35% and the use of alloy steels should be minimized or avoided completely. Welding problems increase in direct proportion with hardenability. This does not infer that welding of such steels is not done, because some organizations have developed suitable techniques to weld these materials.

Sulfur or selenium added for easier machining, is detrimental to sound welds and none of the screw stocks are recommended for this purpose. C-1117 approaches a compromise between machinability and weldability, but it should never be used in hydraulic or pressure vessel applications due to porosity in the weld bead.

C-1018, 4615, 4620, and 8620 (before case hardening) can be welded, but neither E-3310 or Nitralloy 135-Modified are recommended because of their relatively high hardenability.

Welding of any steel with a hardenability higher than C-1018 is easier when a lime-ferritic (low hydrogen) electrode with an analysis approaching the parent metal is used. Two weldable through-hardening steels are discussed later in Group 2.

9 *What is the machinability factor?*

Without chip-breaking elements such as sulfur, selenium or lead, machinability generally decreases as hardenability increases. These three elements are added to attempt to improve the machinability of alloy steels and to make carbon steels free machining. There are disadvantages of some of these additions, however.

Sulfur reduces the transverse impact strength of steels sharply and lowers the fatigue strength. It also forms sulfide inclusions which may become stress-raisers and lead to premature failure.

This does not mean that a resulfurized steel is unacceptable, but it does mean that any part made from it should be carefully evaluated for the type of loading to be encountered in service.

Selenium also forms an inclusion which strings out in the direction of rolling and produces the same type of lowered impact and fatigue properties as sulfur.

Thus far there has been no evidence that lead (range 0.15/0.35%) has any deleterious effect. Impact tests show it to be equivalent to its non-leaded counterpart.

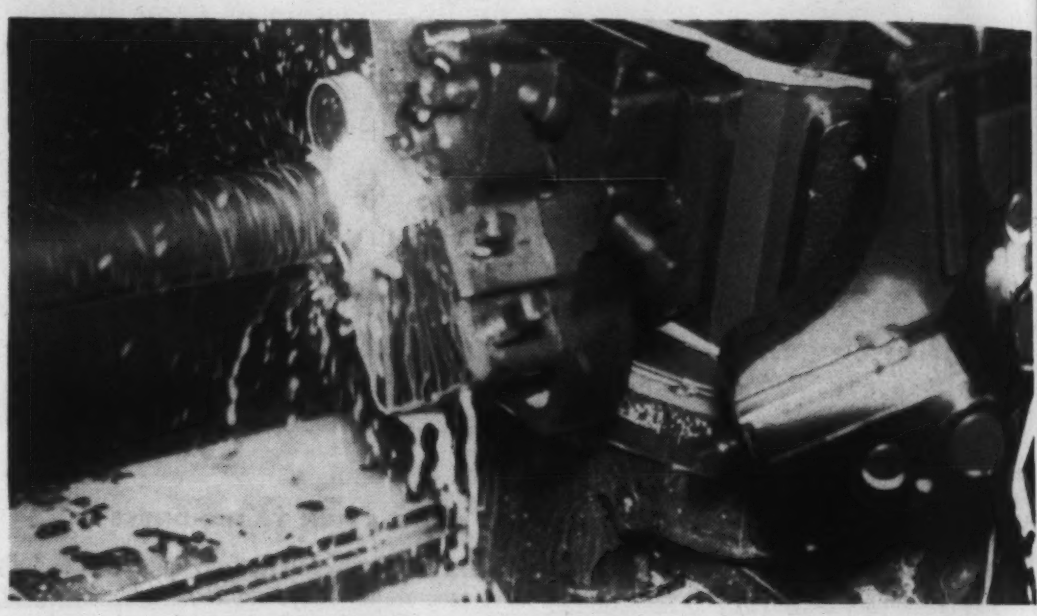
10 *What is the cost factor of the steel?*

The cost factors shown in line 10 are based on B-1112 and C-1212 as 1.00 so that an equivalent comparison between cost and machinability is available. All other factors being equal, cost is the deciding one. Cost data are subject to change. When more than nominal amounts of material are involved an up-to-date quotation should be obtained. Both hot rolled and cold finished factors have been shown where applicable. Only one factor is shown if the steel is sold in only one finish. The cold finished factor means either cold drawn or turned and polished. It does not refer to special finishes such as turned, ground and polished or to special accuracy tolerances.

SELECTING STEEL FROM GROUP 2

5 *What surface hardness and/or core strength is required?*

Today so many direct quenching steels are either flame or induction hardened or first furnace treated and subsequently flame or induction hardened that case and core hardnesses are shown for all steels in Group 2. The core hardness represents the practical maximum hardness obtainable by furnace heating and refers to that which penetrates throughout, consistent with hardenability and quenching in the proper medium. The surface hardness represents the practical maximum obtainable by either flame or induction heating followed by a water spray quench and refers only to that produced by localized heating.



Milling machine spindles *made from annealed Rycut 40. They are roughed on a turret lathe at 964 rpm using a feed of 0.022 in from 1⅞ in. cold-drawn bar stock. Then a blind hole is gun-drilled to a depth of approximately 18 in. Threading and slotting follow. The spindles are quenched and tempered to approximately Rockwell C44, ground and the splines are milled.*

Any one of the steels in group 2 from 3140 to 6150 inclusive would have been used but Rycut 40 was selected because it could be hardened to the desired value, had sufficient hardenability for the cross-section involved, and had good machinability.

6 *What is the largest cross-section of the part?*

This requires knowledge of the hardenability of the steel. Hardenability plays a much larger role in the direct hardening types than it does in the carburizing types. In the case hardening grades we develop our surface hardness through the addition of carbon or nitrogen to the surface, but in the direct quenching types the surface hardness is a function of the section size and the hardenability of the steel, all other things being equal. Thus, a 4-in. diameter section of C-1045 can be quenched in water to a hardness of approximately 400 Brinell, a similar section of 4140 quenched in oil may attain an as-quenched hardness of 534 Brinell, while 4340 quenched in oil may reach 615 Brinell.

In selecting a direct hardening type we must make sure that it will attain the necessary hardness in the required size. Before the part will harden, the temperature must be reduced rapidly throughout the cross-section to a temperature below that of formation of the hard constituent, martensite. The thinner the section the faster heat is removed and the higher will be the resultant hardness.

The function of alloying elements in increasing hardenability is to lengthen the time factor and permit a slower quench. Alloy steels can be quenched in oil and still yield high hardnesses. This reduces the danger of quench cracking or severe distortion and greater depth of hardening is obtained than would result in a steel with lower hardenability.

The maximum hardness obtainable by furnace quenching direct-hardening steels is shown on line 5. The practical maximum shown for C-1045 is Rc 48. This is based on a section size of about 1 in. If we were to quench a 6-in. diameter bar of C-1045 we would find that the as-quenched hardness on the surface had dropped to about Rc 38. This reduction in hardness results from the relative lack of hardenability and is a less important factor as the hardenability of the steel increases. Thus, a 6-in. diameter section of 4340 would quench to a uniform hardness throughout the cross-section near the practical maximum of Rc 55.

7 *Is induction or flame hardening to be used?*

All of the direct quenching types of steel can be hardened by either of these localized heating methods. Frequently, the type of steel used for flame or induction hardened parts has been downgraded in the belief that a carbon steel will suffice for the application. In other cases an annealed alloy steel has been used with only localized hardening. These forms of localized heating and hardening do not change the core strength, or what is more important, the microstructure of the core area. An annealed or as-rolled structure in steel is not intended for applications involving stress-loading or shock absorption.

If the loads on the core area are relatively light, a carbon steel can be used successfully. This would apply to any of the carbon types in Group 2 or 3 (C-1045, C-1141 or C-1144-Strain Tempered). At higher stress levels alloy steels, pre-hardened for core strengths, should be used. The pertinent surface areas can be hardened to a much higher hardness than the core area which may be around Rc 26 to 35.

Normally, localized methods of hardening are used to obtain a high surface hardness in a particular zone. For this reason the 0.30% carbon alloy steels such as 4130 or 8630 are not often surface hardened. However, when the practical maximum of Rc 52 is sufficient these grades are satisfactory.

8 *Is welding required in order to fabricate or assemble the part?*

As pointed out earlier, 0.35% carbon is considered to be the maximum for welding without special techniques. All steels in Group 2 with the exception of 4130 and 8630 exceed this limit. C-1045 and C-1141 are the only grades whose hardenability is low enough to consider them easy to weld but the C-1141 is resulfurized and any welds on this type may tend to be porous. The carbon content of the C-1045 is somewhat high for easy welding.

8630 and 4130 find wide application in the aircraft industry because they are both weldable and hardenable. Welding is an efficient method of producing airframes. Sound practice dictates the completion of all welding operations before heat treatment of hardenable alloy steels since the heat affected zone parallel and adjacent to the weld bead does not retain properties produced by heat treating.

Steel 4150 Modified (resulfurized) has the same drawback as C-1141, since any weld tends to be porous even if the hardenability factor is overcome. The lead in 4150-Leaded has no effect on weldability, but adequate ventilation should be provided as a precaution when welding this steel.

9 *What is the machinability factor?*

Machinability is relative. It depends on the type of machining operation, the machine tool being used, and the skill and experience of the operator. These factors are frequently as important as the microstructure and hardness of the material. Often it is assumed that because a material is annealed it will be relatively easy to machine. This is not necessarily true; there is no substitute for experience with a particular steel.

The two steels in Group 2 designed for applications requiring maximum machinability for their type are C-1141 which contains 0.08/0.13% sulfur and 4150 which is either resulfurized (0.06/0.10%) or leaded (0.15/0.35%).

10 *What is the cost factor?*

Let us merely repeat that where more than a nominal amount of material is involved the price be checked on an up-to-date basis.

If the answer to Question 3 was, yes, the proper steel will be found in Group 3.

SELECTING STEEL FROM GROUP 3

5 *What hardness and/or strength is required?*

In answer, it might be well to start by noting that there are three ranges of heat treated bar stock in general use. The first covers the range from Rc 21 to 26, the second from Rc 26 to 32 and the third from 30 to 36. Thus, the hardness and strength properties available are restricted.

6 *What is the largest cross-section of the part?*

Steel with sufficient hardenability must be used to make parts from pre-heat treated stock. If the depth of hardness penetration into the bar stock is insufficient, the hardness on the face of the finished part may be significantly reduced.

For steels shown in Group 3, C-1144 Strain Tempered would be satisfactory up to about 3 in. dia., 4140 Heat Treated up to about 6 in. dia, 4150-Modified Heat Treated to about 8 in. dia and 4340 up to about 9 in dia. These figures depend, of course, on precisely where the hardness is needed and on the hardness tolerance specified.

7 *Is induction or flame hardening to be used?*

Many parts are induction or flame hardened after being machined from pre-heat treated bar stock. This can be done with gears if the tooth flanks need greater wear resistance than is obtained in the steel as received (maximum Rc 36).

8 *Is welding required to fabricate the part?*

Welding of heat treated bars is poor practice because the high temperature softens a zone adjacent to the weld and leaves a weak area which will precipitate failure. In many plants with limited machining and heat treating facilities, welding is used to repair broken shafting. Failure generally results in a short time and the part must be replaced. The saving resulting from welding is usually more than balanced by the down-time and lost production when a second failure occurs.

9 *What machinability is required?*

This is probably the most important question in deciding which steel to use in this group. With increasing hardness, the problems of machining also increase but not in proportion. For most turning operations Rc 36 is not an insurmountable obstacle particularly on newer turning equipment having sufficient horsepower and rigidity.

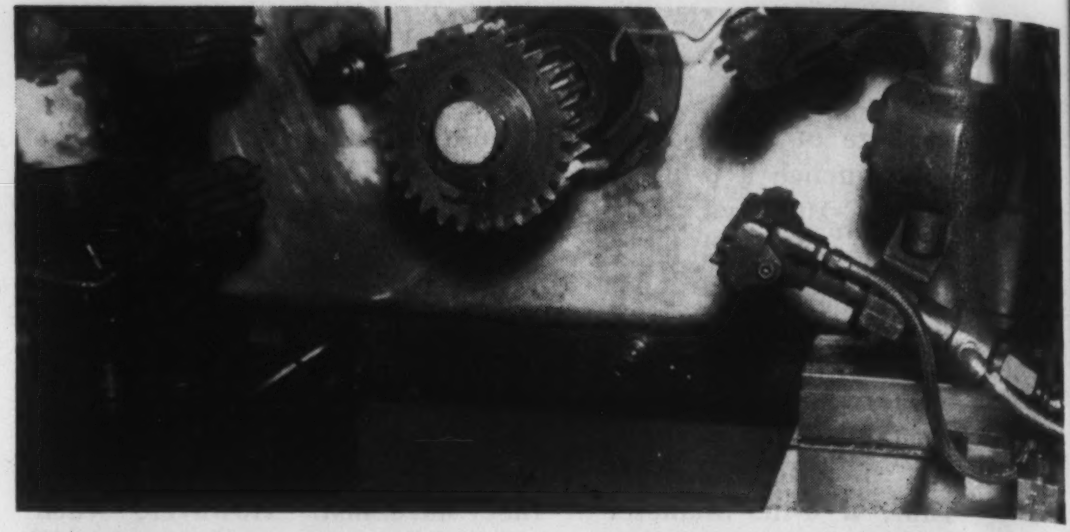
Automatic screw machines might be an exception because the hardness may necessitate such slow turning speeds that these normally high speed units become inefficient from a production and retooling standpoint.

Harder and harder materials are being cut as better grades of carbide and high speed cutting materials become available and broader knowledge of the proper tool geometry is obtained.

Increased hardness causes the most difficulty where an intermittent cut is taken such as in milling, broaching or hobbing. Fine drilling and tapping may cause some initial problems until the proper method is developed.

Several factors are significant if pre-hardened stock instead of annealed material of the same analyses is to be cut: 1) greater tool wear and lower rates of production from the machine tool will result, 2) final tolerances, particularly pertaining to straightness in shafts and spindles, tooth form and back-lash allowance in gears will be closer than obtainable by cutting from annealed stock, followed by heat treating without additional machining, 3) setup costs are lower when pre-hardened stock is used since the parts can often be finish-machined without a break in production for heat treatment, 4) operations after heat treatment such as shaving or grinding can often be minimized or eliminated.

Hardnesses above Rc 36 have not been accepted by most consumers as commercially machinable. However, machining at Rc 50 of many parts has been done by individual manufacturers and one organization mills splines on shafts, in production quantities, at Rc 44. Guiding factors are nature of machining operation, adequacy of machine tool and the operator's experience.



Newspaper press gear *made from 4150 Modified (resulfurized) ready for flame hardening. Gear blank is cut from annealed stock and quenched and tempered to Rockwell C 28/32. Teeth are cut and flame hardened by spinning and drop quenching into oil. Stress relieving at 350 F usually follows. 4150 Modified was selected to give maximum machinability in both the annealed and heat treated condition, and to produce a maximum hardness when flame hardened and oil quenched.*

Sulfur or lead is generally more effective in increasing machinability in hardened stock than it is in annealed stock of the same composition and structure.

Pre-heat treated bar stock should be stress relieved after all mechanical straightening operations have been completed. Bars frequently bend during heat treatment and stresses are set-up when they are straightened. Unless these locked-up stresses are relieved by thermal treatment before machining, they will be relieved during machining causing "springing" of the part. The higher the ratio between diameter and length of the part the more important this becomes.

Mechanical straightening tends to lower the elastic limit and ductility of the steel. Stress relieving restores these properties to their original values.

10 *What is the cost factor of the steel?*

Material cost for pre-heated treated bar stock is not much higher than for annealed stock but machining cost and tool wear will usually be higher. Minimum set-up costs, elimination of grinding, and saving of subsequent heat treating charges will reduce these costs.

SELECTING A STEEL FROM GROUPS 1, 2 or 3

5 *What hardness and/or strength is required?*

The properties of hot rolled steels depend on the finishing temperature, etc., while those of cold drawn stock depend on the amount of cold work the bar received. Available property ranges are therefore somewhat limited.

In general, an alloy steel should be used only for heat treated parts. Most alloying elements impart their properties only after quenching and tempering and thus are generally ineffective in steel not heat treated.

Therefore, the selection should be made from one of the carbon steels marked "OK" in line 4. This includes C-1018, B-1112 or C-1212, B-1113 or C-1213, C-1117, Ledloy in Group 1 and C-1045 or C-1141 in Group 2. C-1144 Strain Tempered in Group 3 fits this category also since it derives its strength from severe cold drawing followed by tempering rather than from quenching and tempering.

Since heat treating is not involved, questions 6 and 7 can be disregarded.

8 *Is welding required to fabricate the part?*

When welding is required, a carbon content of less than 0.35% is desirable. In the steels under consideration, C-1018 or C-1015 would be preferred.

9 *What machinability is required?*

Screw machine products are typical of parts where no heat treatment is usually needed. Basic requirements are maximum machinability consistent with cost. Stresses on such parts are usually so small as to be negligible.

Fractional horsepower motor shafts are also typical. The usual material is C-1045 or C-1141. These have sufficient strength as-rolled for their intended service and are low cost materials.

Hot rolled or cold finished carbon grades like C-1018 or C-1015 are frequently used where minor machining is involved and the parts are lightly stressed. They find wide application in structural and ornamental iron shops because of ease of welding and machining. They are used also in certain hydraulic applications where low sulfur content promotes freedom from porosity. Both grades are used for cold forming operations such as bending, swaging and flattening where cracking must be minimized.

C-1117 is often employed as a *compromise steel* in shops where a material is used either as-received or case hardened, and the quantities produced make the relatively poor machinability of C-1018 undesirable. Selection of a single steel minimizes stocks and prevents mixups following expensive machining operations.

C-1141 is designed as a replacement for C-1045 where production quantities are larger and production speed combined with better tool life are advantageous. Where machine tools are verging on obsolescence, the freer machining qualities of C-1141 permit an acceptable part to be produced. It is also used in job shops as a medium strength, low cost material which reduces machining costs and permits lower quotations on the finished part.

10 *What is the cost factor of the steel?*

Cost of these steels lies within a fairly narrow range and other factors, such as machinability, generally are used for selection of the steel unless very large quantities of parts are involved.

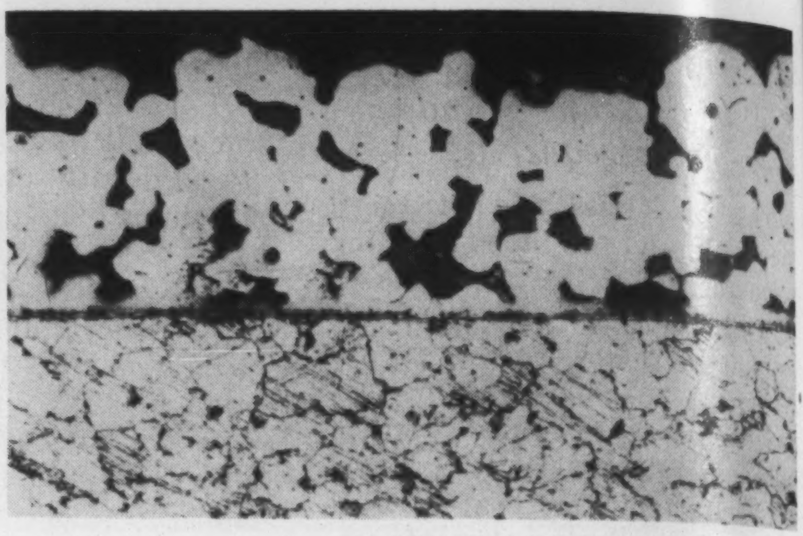
How Right Steel Was Picked for Cam Follower Stud

Application demands a steel to resist surface wear caused by the hardened roller turning on its shank. The threaded end must be ductile. The head must not shear off in the event play between roller and head is great enough to permit a hammering action or in case the stud is pulled up too tightly against the roller. The stud must be able to absorb shock if it is to be used on a cam with a sudden lift and a short dwell (repeated shock). Maximum diameter is ¾ in. The hardness of the stud must approach that of the roller which is approximately Rc 60. Although a through-hardened steel could be used in this application, a case hardened steel would probably give better results.

Following the questions—The part is to be case hardened; thus the steel is in Group 1. The core strength must be in the medium range to prevent shear breakage and absorb shock (Rc 25 to 35). Thus 4615, 8620 or 4620 would apply and the hardenability of all three of these grades is sufficient for the ¾-in. cross-section. Neither induction nor flame hardening is intended nor is welding to be used. Thus the decision is based on relative cost and machinability. The 8620 has slightly less machinability than the other two but also is lowest in cost. Quantity of parts to be produced and desired rate of production determine whether machinability or cost is the deciding factor.

Carbon drill rod or tool steel are used occasionally in this application but are not recommended because a through-hardened structure may be too brittle to absorb shock or may cause a fracture at the junction of the head and shank.

Fluorocarbon ➡ + Porous Bronze ➡ + Steel Backing ➡ = New Dry Bearing Material



A New Materials Preview

■ The excellent friction, chemical and wear properties of fluorocarbon plastics are combined with the strength, thermal conductivity and dimensional stability of metals in a new series of dry-bearing materials developed recently in England, and obtained by impregnating a porous metal matrix with polytetrafluoroethylene resin.

In a continuous process a thin layer of graded bronze powder is applied to a suitably prepared steel strip and sintered in a reducing atmosphere. The porous bronze surface of the resulting bi-metallic strip is then impregnated with fluorocarbon resin by a process developed and patented by Glacier Metal Co., Ltd., Alperton, Middlesex, England. The resulting structure consists of steel backing, a mechanically interlocked network of bronze and fluorocarbon resin and a thin surface of pure resin. Thrust washers, bearings and bushings are then blanked, pressed and machined from the strip by conventional methods.

For bearing applications, polytetrafluoroethylene by itself is limited to light loads and low speeds due to its poor thermal conductivity, poor temperature stability as compared with metals, high coefficient of thermal expansion, tendency to cold flow and its elastic memory. Porous bronze and solid steel backing help carry off heat generated during service and provide support and dimensional stability lacking in the resin. The thin surface layer of resin provides initial bearing surface of sufficient thickness to fill any roughness on mating surfaces. Should the surface layer of resin become damaged, a local hot spot develops which softens the plastics so it exudes from the porous matrix and "heals" the damaged area of the bearing.

Polytetrafluoroethylene is extremely inert chemically. The only substances affecting it are molten potassium, molten sodium, fluorine gas and certain other fluorocarbons. Impregnated bearings are therefore highly suitable for use where corrosive conditions are encountered. For certain applications other porous metals and backing materials may have to be used.

Bearing characteristics

Load and speed capacity of bearings are determined largely by capacity of the assembly to dissipate heat. In a normal bearing liquid lubricants remove heat from the contact surfaces. In impregnated bearings heat must be dissipated through the resin and metal backing. For a constant bearing pressure (P, in psi) and surface speed (V, in fpm), constant bearing conditions can be expected. In other words, high loads can be carried at low surface speeds and light loads at high surface speeds. The accompanying table of PV factors is based on tests made by Glacier Metal Co.

PV FACTORS FOR IMPREGNATED BEARINGS[1]

Type of load application	Normal PV	PV—under special circumstances
Thrust bearing.	5000	up to 15,000
Journal bearing—unidirectional load.	4000	up to 8000
Journal bearing—rotating load.	16,000	up to 30,000
Journal bearing—oscillating load.	18,000	up to 60,000

[1] *P—Bearing pressure in psi*
V—Surface speed in fpm

on bearings operating against mild steel shafts with good surface finish under conditions ranging in pressure from 5 to 2000 psi and at surface speeds of 10 to 1000 fpm. PV factors shown are substantially applicable at surface speeds up to around 500 fpm. At higher speeds air tends to be sucked in between the bearing and mating surface and acts as a lubricant allowing higher loads to be carried. Other shaft materials such as alloy steels, cast iron, or hard anodized aluminum can produce similar results. PV values can be raised considerably by coating the shaft with lead or chromium plate, a fluorocarbon resin or molybdenum disulfide.

Maximum use temperature for the impregnated bearings is around 600 F, though for most applications ambient temperatures up to 500 F are suitable. Proper cooling of the bearing can raise this temperature.

Though the bearing material is designed for operation without a liquid lubricant, presence of a liquid in most cases will increase rate of heat dissipation and permit more severe operating conditions. Liquids such as water, milk, acids, and solvents are not harmful to the plastics bearing surface, but the metal backing will have to be selected to suit individual applications. If a liquid is to be used, careful consideration should be given to its selection as many fluids will not wet fluorocarbon surfaces and thus will not readily be drawn between bearing surfaces.

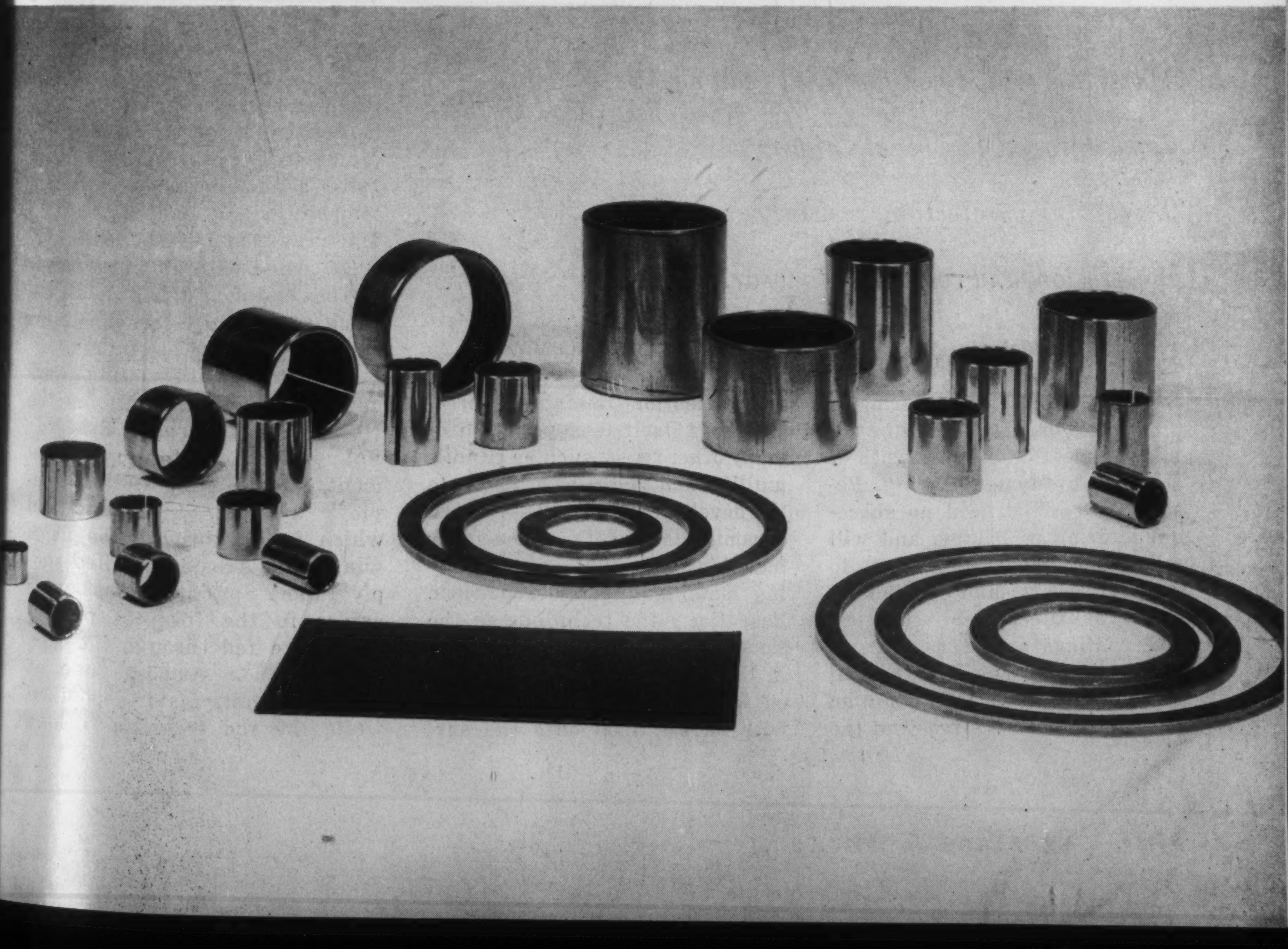
Applications

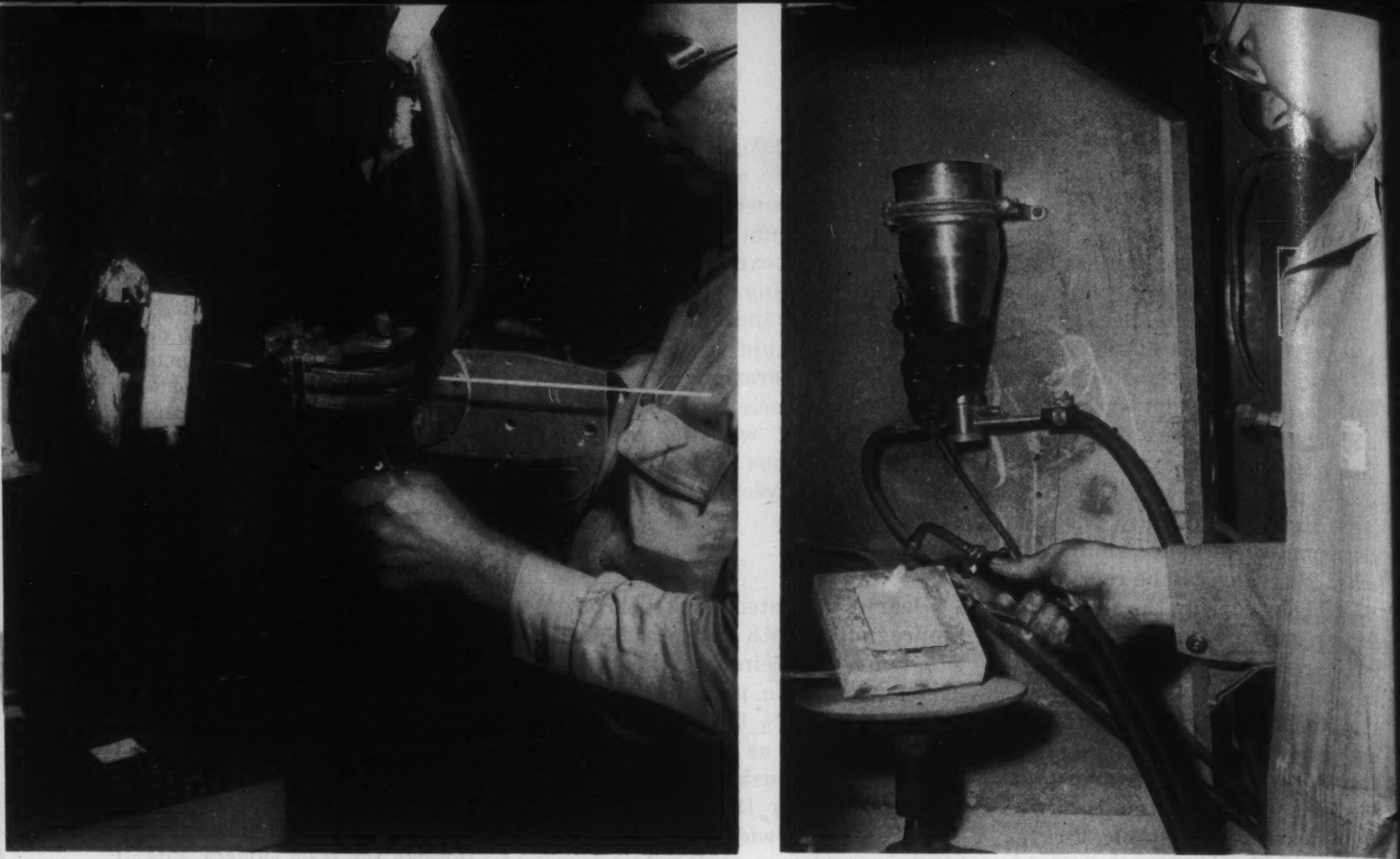
Bearings of steel-backed bronze impregnated with polytetrafluoroethylene are being produced by Glacier Metal Co. in standard sizes ranging from ⅜ to 2 in. in shaft diameter, both as thrust washers and wrapped bushings. Potential applications for the bushing material fall in a wide variety of industries, wherever dry bearings would be advantageous. Possible industries include textile machinery, domestic appliance, food machinery, mining, chemical and process, and aircraft control.

What is Fluorocarbon?

Polytetrafluoroethylene is a long straight chain polymer consisting of carbon and fluorine only. In this country it is produced by E. I. du Pont de Nemours under the trade name Teflon. It has remarkable chemical properties and a dry coefficient of friction against itself or any other material of about 0.05, which is roughly equivalent to that obtained between two pieces of smooth ice. This low friction is a surface property of the material and is not a measure of its shear strength, as is the case with some solid lubricants. Therefore, almost no wear takes place when a smooth surface is rubbed against a smooth piece of the plastics. Any wear which takes place is due solely to the roughness of the mating surface ploughing through the resin surface. Pits and discontinuities making up the roughness should in time become filled with the resin and wear would be reduced even further.

Typical shapes *in background stamped and formed from impregnated bimetallic sheet material in foreground.*





Two methods of flame spraying. *Left, sintered ceramic rods are fed through this metallizing-type spray gun to obtain Norton's hard, abrasion-resistant, high-temperature coatings. Right, ceramic powders are fed through a hopper to a flame gun to apply Armour's ceramic coatings.*

New Flame Sprayed Ceramics

Aluminum and zirconium oxides can now be flame sprayed to provide high temperature protection, resistance to corrosion, and erosion, and resistance to wear.

by Malcolm W. Riley, *Associate Editor, Materials & Methods*

■ Ceramic coatings consisting of pure metal oxides can now be applied to metal and other types of surfaces by flame spraying. Resultant coatings need no subsequent firing or baking, and will withstand temperatures up to around 3000 F and erosion by gases at supersonic velocities. The coatings are hard, wear-resistant and have low thermal conductivity. Oxides of aluminum and zirconium have received the most attention, though the process lends itself to application of many other types, such as titania, mullite and porcelain. Prior to the development of flame-sprayed ceramic coatings, the flame-spray technique was limited to applying metal and cermet coatings. Essentially the technique is the same as conventional metallizing in that ceramic material is melted in a flame gun and sprayed with an air blast onto the surface to be coated. Since the ceramic particles are in a semimolten condition when they impinge on the surface, the base material must be able to withstand temperatures of only 600-800 F. Materials that have been successfully coated with alumina include ferrous and nonferrous metals, ceramics, graphite-carbon, glass and some types of plastics.

The two lines of coatings were developed independently by the Norton Co. and Armour Research Foundation. Norton's development, called Rokide coatings, employs a sintered ceramic rod which is fed through the flame gun, while Armour's, called simply Flame Spray Ceramics, uses oxides in the form of powder which are fed through the gun. According to Armour, use of powder permits faster deposition while the rod technique allows closer control over coating deposition. Coatings produced by both methods appear to be substantially the same.

Physical properties

In general, coatings have the following properties and characteristics:

1. High melting point.
2. High hardness.
3. They are relatively inert chemically.
4. Good mechanical strength.
5. High corrosion resistance.
6. Low coefficient of thermal expansion.
7. Low thermal conductivity.
8. Applicability to a wide range of sizes, shapes and materials.

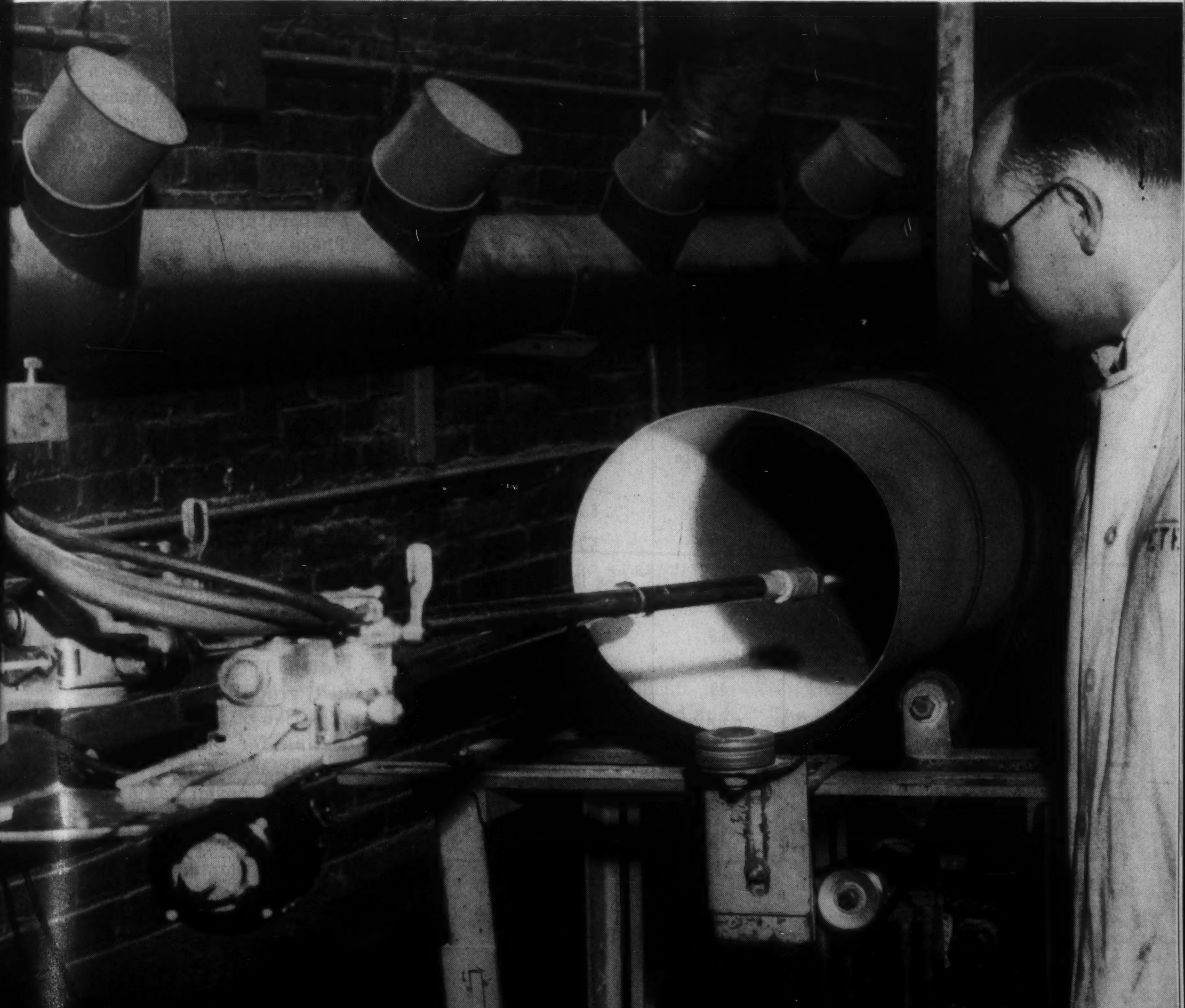
OXIDES vs STAINLESS STEEL

	Aluminum Oxide	Zircon	Stabilized Zirconium Oxide	Stainless Steel
Thermal Expansion, 10^{-6}/°F from 70 to 2550 F	4.3	2.3	6.4	12.2
Thermal Conductivity, Btu/hr/sq ft/in./°F, mean temp. of 1500 F	19	15	8	185
Density, g/cc	3.2	3.8	5	7.8
Melting Point, F	3600	3000	4500	2600
Hardness, Knoop	2000	1000	750	400

Accompanying tables list typical properties of Norton's alumina, zirconia and zirconium silicate coatings as well as values comparing properties of the ceramic materials with those of stainless steel.

The semi-molten condition of the particles as they strike the surface permits them to deform and bond to the cool surface and to other deposited oxide particles. Roughening the base surface prior to coating will improve the bond. As-applied, coatings

Coating technique *developed by Norton for applying ceramic coating to inside surface of ramjet part.*



have a porosity of about 8 to 15%, and alone do not provide perfect protection against chemical corrosion of underlying material. Protection can be increased by use of various additives to the coating or by subsequent over-coating with other ceramic materials.

On curved or tubular surfaces, careful consideration must be given to design of coated components, since ceramics are brittle materials. Their compressive strengths are about ten times greater than their tensile strengths. Tests on coated concave and convex surfaces show that a ceramic coating on concave surfaces such as inside walls of tubing will withstand many more cycles of heating and cooling than will a coating on the outside of the tube.

Most of the data available at present concern aluminum oxide coatings. They can be applied in thicknesses of 0.005 to 0.050 in. In heavier coatings residual stresses may cause coating failure on sudden heating or cooling. Adherence of coatings is good in spite of the fact that the bond is primarily a mechanical one. According to Norton, a 1/16 in. metal sheet with a 0.010 in. coating can be bent at room temperature to a 45 deg angle without destroying the coating. As-deposited coatings have a roughness of a few hundred microinches, though they can be smoothed to about 40 rms by grinding with diamond wheels. Since the coating consists of a chemically stable oxide, it cannot oxidize further at either high or low temperatures and is not readily reducible. It is not attacked by acids or alkalis under ordinary conditions, though its porosity reduces its value for corrosion resistance.

Availability

Both processes are available on a licensing basis. A license for applying Rockide coatings can be obtained by any subscriber by applying to Norton Co., Worcester, Mass. There is no charge for the license, but processors pay a royalty of $1.65 per lb of Rockide rods used. Norton estimates the royalty will amount to an average of 2.5% of cost of the coating operation. The first announced licensee is the Bettinger Corp., Waltham, Mass.

Armour's Flame Spray Ceramics process has been licensed to Continental Coatings Corp. of Ill., 2333 S. Michigan Ave., Chicago, who may sublicense other organizations in the contract applicator field.

Heat resistance of alumina coatings is excellent, since the material melts at about 3600 F. The high temperature resistance coupled with a low thermal conductivity of 19 Btu/hr/sq ft/in./°F at 1000 to 2000 F, makes the coating an excellent thermal insulator for high temperature applications. According to Norton, a maximum temperature drop of 1500 F has been reported through a 0.010 alumina coating under certain conditions. In many cases the base metal can be melted without harming the coating.

Applications

Flame-sprayed ceramic coatings are as yet too new for lengthy field evaluation. Their properties would indicate that the major area of use would be in rocket, missile and jet engine components where extremes of temperature are encountered. These would include nozzles, motor tube linings and thermal barriers in rockets; vanes and skin protection in guided missiles; tail pipe linings in ram jets; and inner combustion chamber linings, cross fire tube lining, flap nozzle coating, housing and shroud ring insulation in gas turbines. They could also be used for protection of burner parts, thermocouple tubes and electrical insulation.

Commercial applications might include coating of pump impellers and housings, fan blades and turbines, and piping subject to cavitation. They could also be used to coat graphite to reduce erosion, oxidation and wear; as a wettable coating for oil burner pans and grates; as a catalyst coating for flame equipment; as a hard coating for softer materials such as aluminum, or mild steel; and as decorative surface coating.

TYPICAL PROPERTIES OF CERAMIC COATINGS

	ROKIDE* A	ROKIDE* Z	ROKIDE* ZS
Chemical Composition, %	98.6 Al_2O_3	98 Lime Stab ZrO_2	65 ZrO_2 34 SiO_2
Crystal Form	Gamma-type	Cubic ZrO_2	Cubic ZrO_2 Silica Glass
Bulk Density, g/cc	3.2	5.2	3.8
True, g/cc	3.6	5.7	4.15
Total Porosity	8–12	8–12	8–12
Thermal Expansion, 10^{-6}/°F (70–2550 F)	4.3	6.4	2.3
Thermal Conductivity Btu/hr/sq ft/in./°F, mean temp of 1500 F	19	8	15
Total Emissivity	0.3–0.4	0.3–0.4	0.3–0.4
Melting Point, F	3600	4500	Glass phase at about 3000 F
Color	White	Tan	Tan

**Trade Name of Norton Co.*

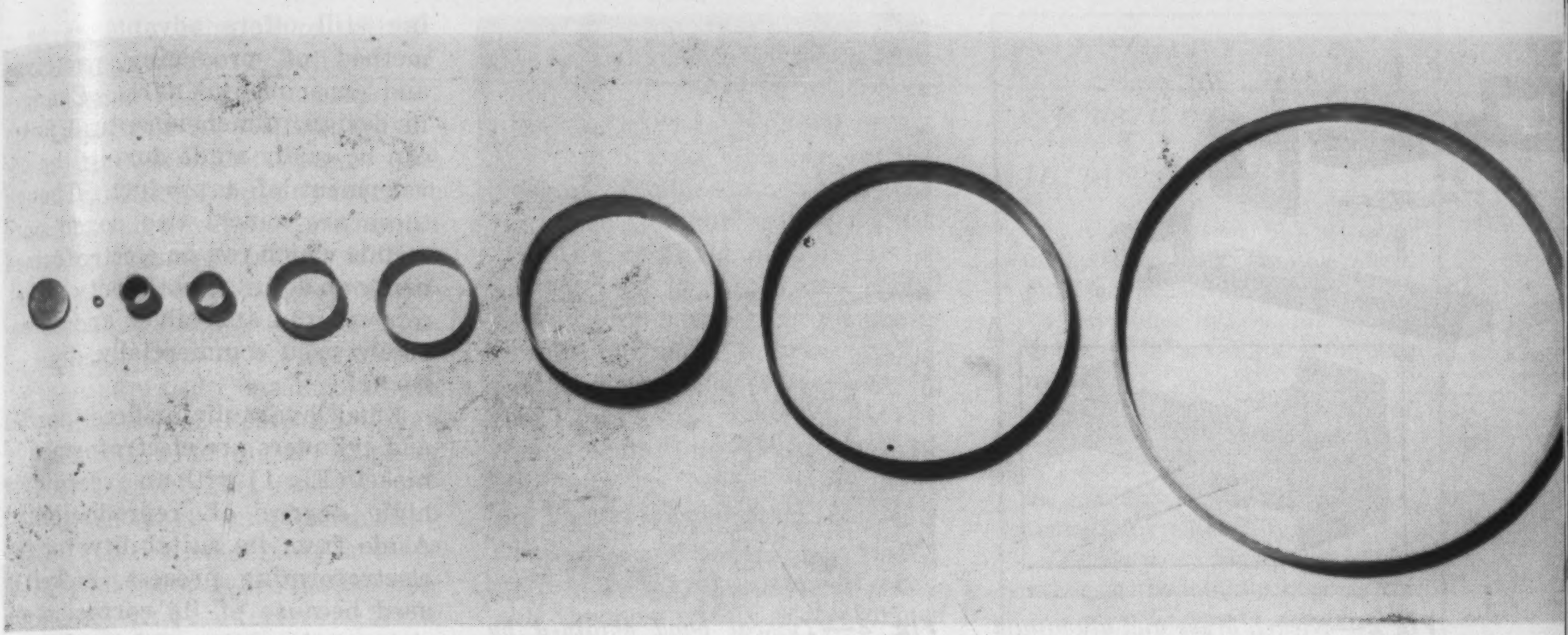


Fig 1—*Nickel hydraulic components indicate close dimensional control obtainable by electroforming. From left to right, spray nozzle with 0.002-in. ports, 0.020-in. restrictor orifice, 0.500-in. dashpot cylinder, 1-in. viscosimeter barrel, float switch barrel, pressure switch cylinder and 6.75-in. concentric barrel.*

A New Look at Electroformed Parts

Once limited to specialty products, electroforming is now being used for many production parts where these requirements must be met:

- *Exceptional surface finish or detail*
- *High precision*
- *Complex internal design*

by H. D. Rice,

Vice President and Technical Director, Gar Precision Parts, Inc.

■ Though originally limited to prototype and extremely critical short run production, electroforming has been refined to the point where often it can be economically competitive with other methods of precision metal forming. Developments include: 1) increased control over physical characteristics and stress of deposits; 2) increased speed and efficiency of metal forming; 3) widening the number of shapes that can be practically produced; and 4) extending the number of materials to which deposits can be bonded.

Where does it fit?

Electroforming is suitable for forming parts where difficult internal operations are involved and where dimensional accuracy and finish are critical. In this respect it is probably more nearly competitive with investment casting than with any other production method. In many cases, part-for-part production of individual components of an assembly by electroforming will be more expensive than with other methods. However, many products produced as assemblies can be redesigned to allow them to be produced as one electroformed part, eliminating several steps of fabrication, finishing and assembly. Frequently this will provide additional advantages from the design standpoint.

Tooling costs for electroforming are no higher, and in many cases are lower, than tooling for investment casting. Although tank time may run to many hours, it is not a large cost factor. Cost per piece can be substantially reduced by "ganging" in the bath, producing a number of parts simultaneously. The number of parts that can be produced by grouping is determined by the size and configuration of the parts and the size of the bath available.

In addition to its production economies, of course, electroform-

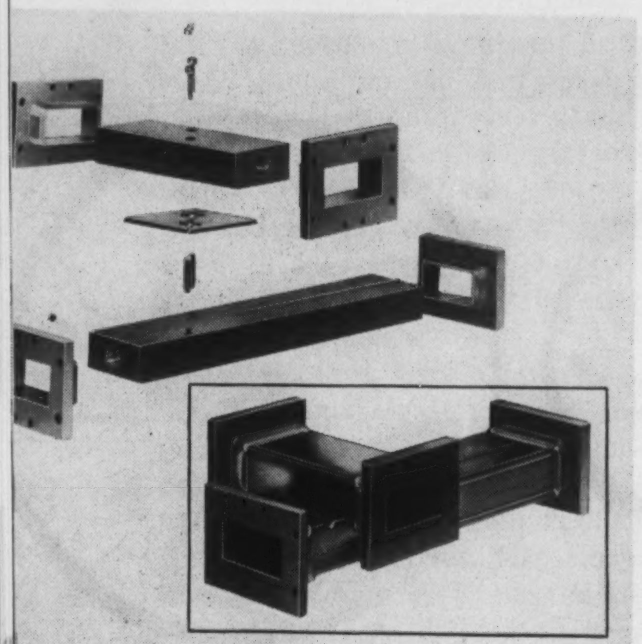


Fig 2—*Nickel, brass and aluminum join in microwave coupler "grown in place" around expendable mandrel. Brass and aluminum components are machined and nickel is electroformed around them.*

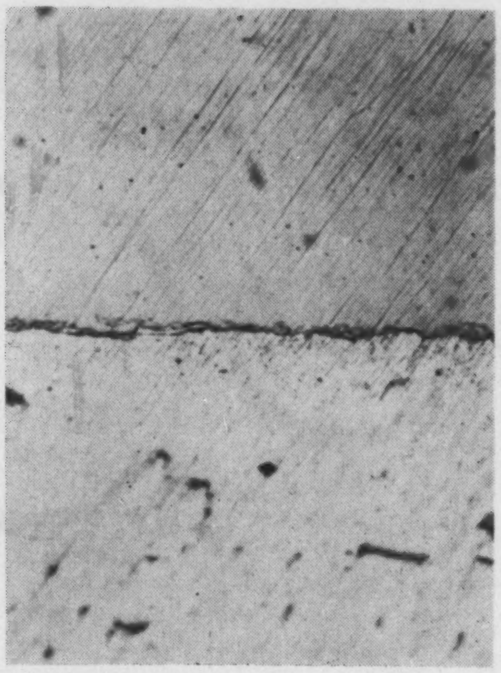


Fig 3—*Typical bond obtained by electroforming nickel on aluminum (x500). Aluminum is at top, nickel at bottom.*

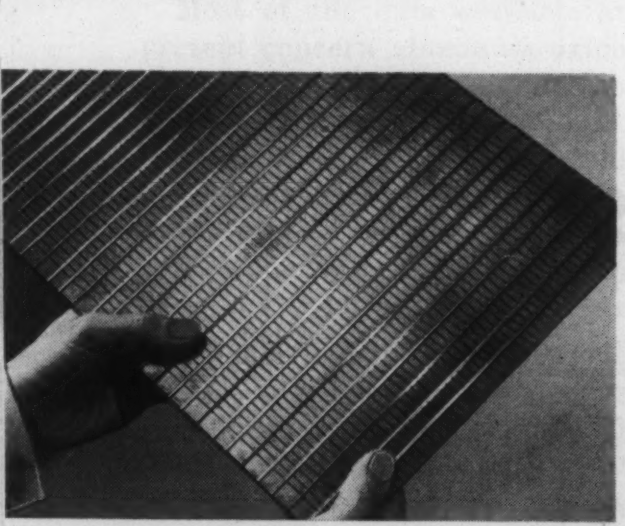


Fig 4—*Nickel pallet mold illustrates practicality of electroforming in reproducing intricate dies where special processing conditions are encountered.*

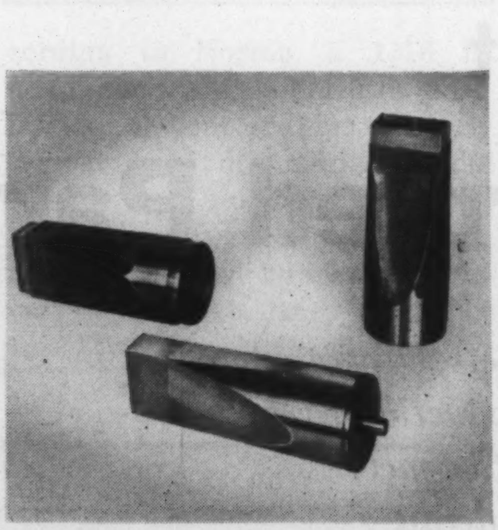


Fig 5—*Copper wave guide transition electroformed over stainless steel mandrel illustrates method of producing precisely machined external surfaces concentric with internal.*

PROPERTIES OF ELECTROFORMED METALS

	Nickel	Copper	Iron
Ten Str, psi	125,000	31,400	50,000
Elong, % in 2 in.	20	15	25
Therm Coef of Lin Exp, per °F	0.05566	0.05926	0.056611
Therm Cond, at 32 F, Btu/hr/sq ft/°F/in.	408	2680	500
Hardness, Brinell	352	110	120-140
Density, lb per cu ft	553	555	492
Mod of Elast, 1,000,000 psi	31.2	16	25.5
Corrosion Resistance	Excellent	Fair	Fair to Poor

ing still offers advantages as a method of producing prototype and experimental parts. Changes in design, dimensions, and finish can be easily made during the development of a product. Though there are almost two dozen pure metals which can be electroformed using an aqueous bath, only nickel, copper, iron and silver are extensively used commercially.

Nickel

Small hydraulic orifices, nozzles and cylinders are electroformed in nickel (Fig 1) with an exceedingly high degree of reproducibility. Aside from its suitability for the electroforming process, nickel is used because of its corrosion resistance, hardness and good density characteristics which provide sharp clean edges. Nickel is built up to approximately 0.050 in. on a centerless-ground and lapped steel mandrel which serves as the cathode. The nickel tubes are cut while still on the mandrel to ensure sharp edges and eliminate distortion, and the mandrel is removed. Tubes are then pressed into appropriate fittings and assembled as required. Electroforming permits a remarkable degree of reproducibility, yet imposes no limitation on the quantity of production parts produced with the same tooling. Over 3000 units of this type have been produced in a week.

The nickel microwave coupler shown in Fig 2 is produced by a technique known as "growing in place". It consists of four aluminum flanges and an internal brass iris plate which are assembled on an expendable mandrel cast of a low melting point alloy. Nickel is then electroformed around the flanges, plate and mandrel, forming a one-piece component. Melting out the mandrel is the final step in production. The aluminum flanges are machined to dimension prior to assembly, and the brass iris plate is punched and shaved holding tolerances of ±0.0002 in. Over-all internal dimensions of the finished coupler are held to ±0.001 in. and internal surface finish is 8 rms throughout. During electroforming, careful control of bath formulation, current density, anode positioning and movement of electrolyte in relation to cathode produce a uniform build-up of nickel along edges of the coupler. The resulting girder-like formation provides high strength and rigidity, while permitting thinnest possible wall thickness to minimize weight and material. Type of bond obtained between the electroformed nickel and aluminum or brass is indicated in Fig 3. Use of this method offers obvious advantages in elimination of distortion during fabrication, widening the types of metals that can be used in electroformed parts and permitting use of external machining methods for forming otherwise inaccessible intricate part interiors. While meeting stringent mechanical and electronic requirements, electroforming has lowered unit cost of these parts from about $175 to $95.

The pallet mold (Fig 4) for manufacturing fused glass electronic components is being electroformed in nickel in production runs in excess of 2500 units. Nickel is used because its coefficient of expansion closely corresponds to that of the glass, avoiding cracking and distortion as the mold is heated and cooled during production. After machining the master or matrix, production masters are electroformed. On these production masters, several sheets containing ten or more individual 10 x $1\frac{1}{2}$ in. pallet molds are electroformed simultaneously.

The Electroforming Process

Electroformed parts are produced by electrolytic deposition of metal on a conductive pattern. Resultant parts conform atomically to the shape and surface of the pattern. Metal is supplied by compounds in the electrolyte and a bar of purified metal suspended in the bath to act as the anode for the plating current. Electroforming differs from plating in that solid parts are produced with thicker deposits which are later separated from the pattern. Deposited metal exhibits high purity and density with a long, needle-like crystal structure typically aligned at 90 deg to the pattern surface.

A wide range of hardness, ductility and tensile strength can be produced by controlling bath content, rate of deposition, agitation and other bath variables. Though heat treatment of formed parts is possible, it is usually unnecessary. Almost two dozen pure metals can be electroformed in aqueous baths, though nickel, copper, iron and silver are the only ones used in commercial production.

Copper

Next to nickel, copper is probably the most widely electroformed metal. A good example of a large electroformed copper component is the 12 in. microwave transition (Fig 5). Circular-to-rectangular transition area of the interior is held to $+0.002$ and -0.000 in. tolerances at stations $\frac{1}{4}$ in. apart throughout its length. Wall thickness averages 0.100 in. The part is formed on a stainless steel mandrel the turning centers of which are used to hold the part for external machining of the end areas. This technique assures a high degree of concentricity between inside and outside surfaces. The mandrel is then removed by making use of the difference in expansion coefficients between the steel and the copper part. Since electrical characteristics of these transition pieces change with changes in dimensions and finish, uniformity is vital to predictable operation of the component.

Iron and silver

Electroforming in iron has been predominantly used for salvage and build-up applications and in molds for plastics. The U.S. Bureau of Printing and Engraving uses electroformed iron printing plates to maintain optimum accuracy in producing paper currency. In the event of war-time material shortages, many parts currently produced in nickel or copper could be made in iron, or could consist of a laminate of a relatively thin deposit of the critical material backed with iron.

Where high conductivity is required, as in certain small, extremely high frequency radar waveguides, silver is desirable either in solid form or as the interlayer of a laminate. However, its high cost limits its use for many applications.

Consider electroforming when . . .

. . . *high precision,* in the range of 0.002- to 0.0002-in. tolerances must be held.

. . . *complex internal areas* are inaccessible to ordinary forming methods.

. . . *surface finish* in the range of 8 rms or under is mandatory.

. . . *intricate surface detail* must be exactly reproduced either internally or externally.

. . . *thin walls* make forming by other methods difficult or costly.

. . . *metallic purity* and freedom from foreign elements is essential.

. . . *prototype quantities* would preclude other methods due to high set-up and modification costs.

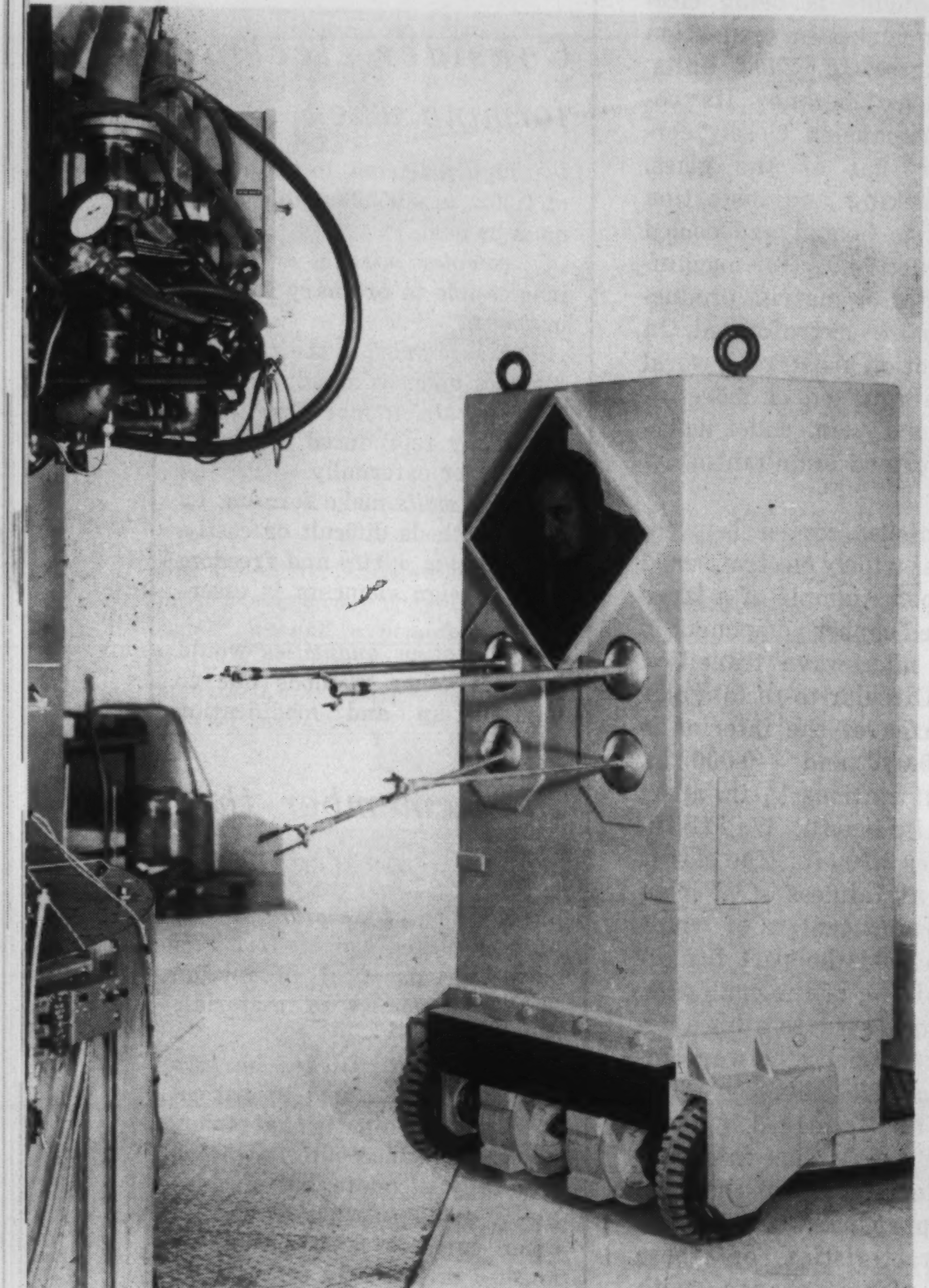
But remember that limitations are . . .

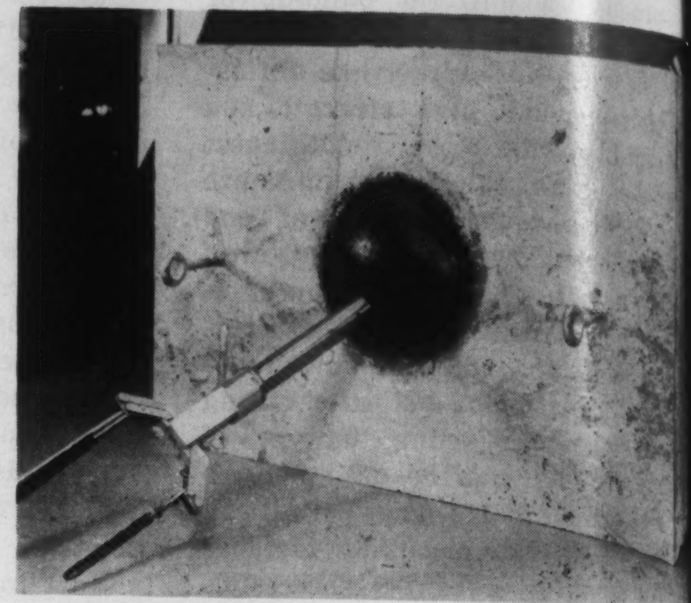
. . . *selection of materials* is confined to nickel, copper, iron and silver for practical production due to economics of materials costs.

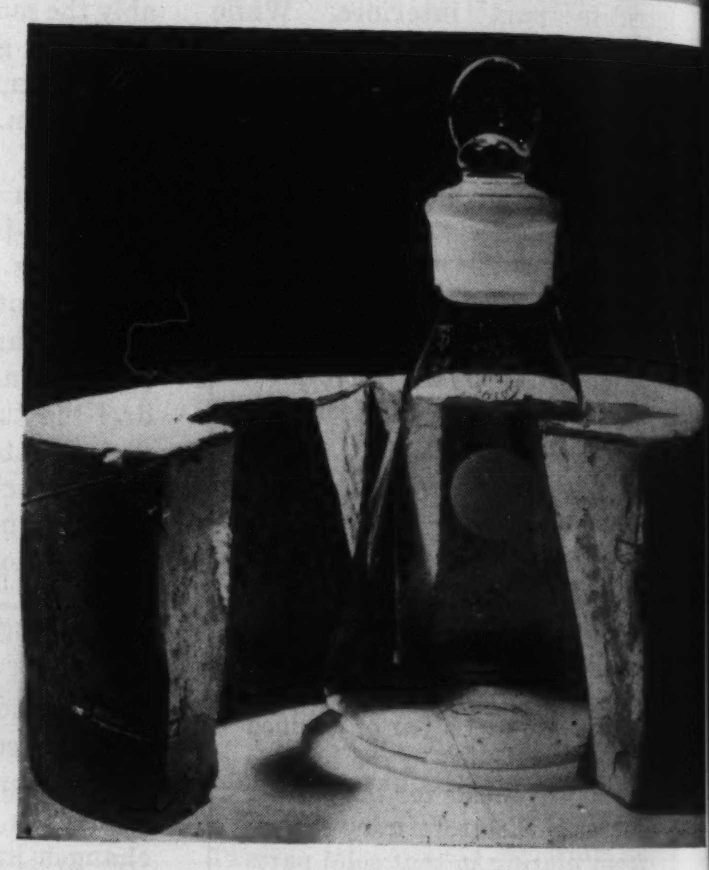
. . . *only one finished surface* normally can be held to critical surface and dimensional tolerances. As-formed external finish is usually adequate, but machining or grinding must be used if other surfaces must be highly finished or precisely concentric.

. . . *rate of production,* that is part build-up, is relatively slow. However, where part size and shape permit, ganging in the tank can greatly accelerate production volume.

. . . *shapes are restricted* to those with bosses or projections which are wider than they are high. These appear as grooves or recesses in the matrix and generally metal cannot be electrodeposited into recesses which are deeper than they are wide.







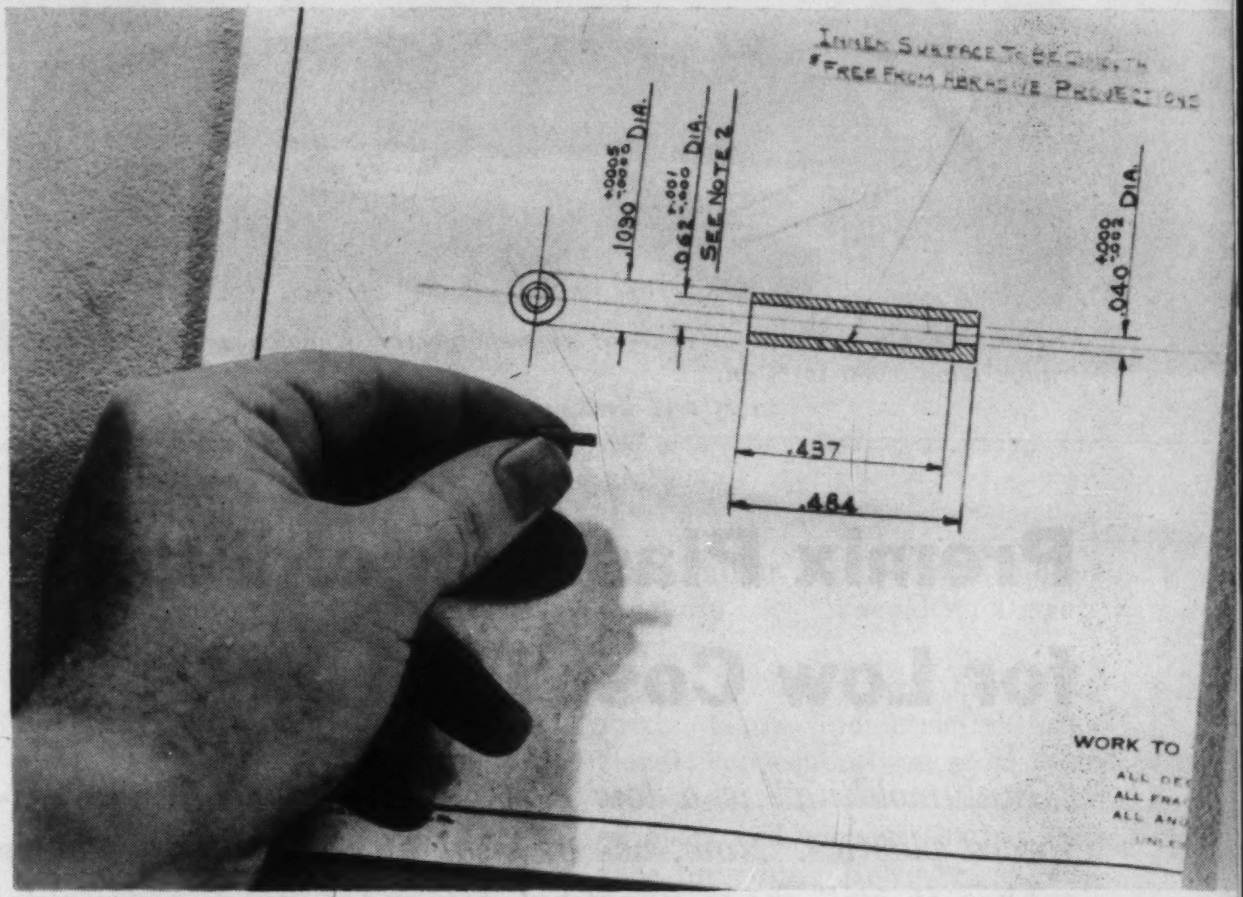
Lead, Cement Guard Against Radiation

Development of a cold-setting lead cement mixture solved a seating problem in the ball-joint sockets of a mobile radiation shield (left) at the Argonne National Laboratory. The problem was to find a way of seating the ball so that manipulators could operate freely, while at the same time maintaining shielding integrity of the assembly. The new mixture is made up of lead shot and powder, cement and water.

Water and cement are first mixed to a slurry, after which lead powder and shot is mixed in to form a uniform dispersion. The mix sets slowly permitting small batches to be poured at a time. Forms can be removed from 16 to 24 hr after pouring. Rotating parts cast into place are grease-coated, and rotate freely within 8 to 12 hr after pouring as shown at upper right. After setting for 30 days, compressive strength of the mixture ranges from 2200 to 2500 psi and shielding properties are approximately 1¼ times as effective as steel for gamma ray energy up to 1.33 mev. Other applications for the material are suggested by the flask shield shown at lower right.

Accuracy in Plastics

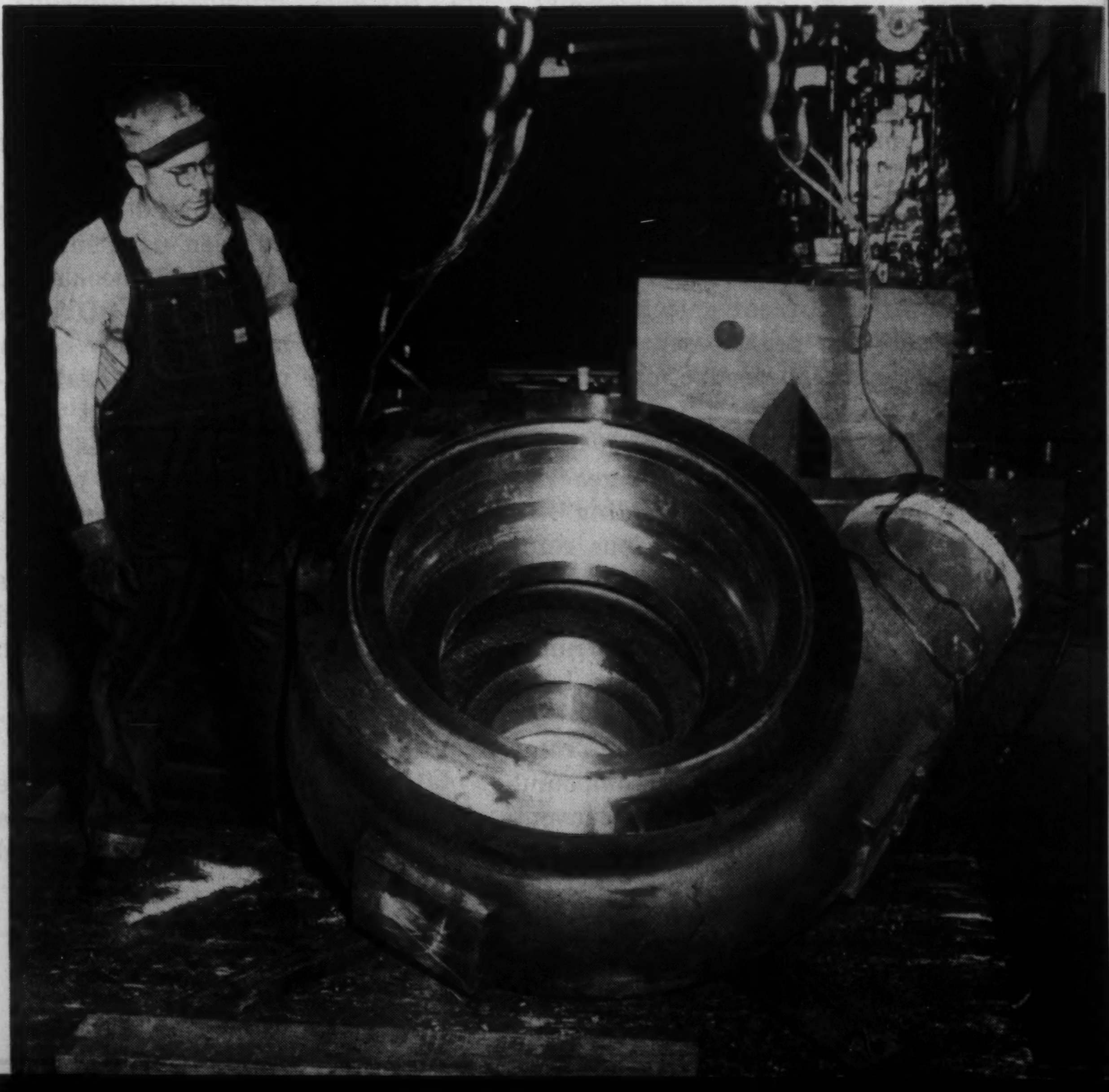
The high degree of as-molded accuracy possible in plastics parts is exemplified by this molded alkyd spring holder being mass-produced for the government. Tolerances in the ten thousandths are indicated on the print. Concentricity of o.d. and the larger i.d. must be held within 0.0005 in. Part is being molded by Mason, Shaver & Rhoades of E. McKeesport with a Plaskon alkyd material produced by Barrett Div., Allied Chemical and Dye Corp.



Cast Stainless Pump Casing

With a wall thickness of 4 in., an o.d. of 38.5 in. and an over-all height of 25 in., this casing for a double volute pump is cast in ACI type CH-8C alloy (0.08 max carbon, 12-15 nickel, 22-26 chromium and 10xC% columbium). Close control of alloy constituents keeps ferrite content low enough to prohibit sigma phase embrittlement resulting from welding during assembly into piping system.

Designed by the Atomic Equipment Dept. Westinghouse Electric Corp., the casting must withstand a 4650 psi hydrostatic proof-test with zero leakage; radiographic examination to reveal internal quality within ASTM E71-Class 2 requirements; and other chemical and physical tests. Casting must be in accordance with ASME Power Boiler and Unfired Pressure Vessel code, Section I.



Typical parts *made from sisal- or glass-polyester premix. Sections generally range from 0.090 to ⅜ in.*

Premix Plastic Moldings for Low Cost Parts

"Gunk-molding" is a low cost method of molding reinforced plastics. Now, use of sisal fibers instead of glass makes it still more practical for mass produced parts.

by John B. Campbell, *Associate Editor, Materials & Methods*

■ Reinforced plastics may not yet be practical for major body panels, but they are becoming more and more widely accepted for other, less spectacular applications in mass-produced cars. Behind this current growth are two important developments: 1) a low-cost, high-production molding process, and 2) a low-cost material.

The molding process is generally known as "premix molding". In premix molding, the fibrous reinforcement is not in the form of a mat or cloth, but rather in the form of short, chopped strands mixed uniformly with the polyester resin, fillers and other ingredients of the molding compound. This putty-like compound or "gunk" is molded by conventional compression or transfer molding techniques.

Premix molding itself is not a brand new process. For several years, glass-reinforced polyester premixes have been used in various electrical and mechanical parts. However, most of these parts have been relatively small, and it was not until Woodall Industries began turning out thousands of large, sometimes complex parts daily that premix molding achieved the stature of a major process.

Premix-molded parts are not as strong as mat- or cloth-reinforced parts. Where lower strength can be tolerated, however, premix-molded parts offer some significant advantages:

1. Complex parts can be made more economically. Details such as holes, slots, grooves, tapers and bosses can be molded in; thus, a single part may suffice where an assembly of many parts might otherwise be required.

2. Production is more rapid; press cycles are only about one-half to one-third as long as in wet layup because dies can be loaded and unloaded more simply.

3. Preforms or die-cut mat blanks are not required.

4. Less material is wasted because it is possible to weigh out the correct charge in advance.

5. Premixing makes it possible to control more easily the relative proportions of resin, fiber and fillers.

6. Molding materials are cheaper because the reinforcing fiber may be obtained in its simplest and least expensive form.

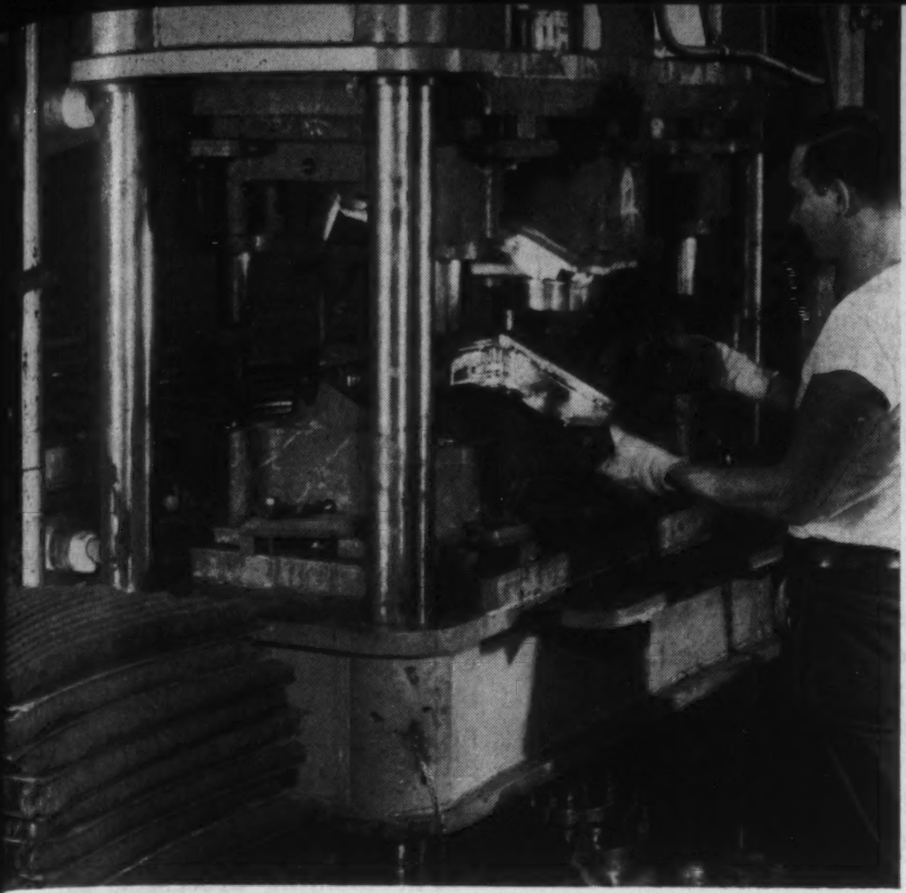
7. Since the reinforcing fiber need be available only in its simplest form, a greater variety of reinforcing fibers can be used.

This last point is an important one. A majority of the premix parts now being made by Woodall are reinforced not with glass but with sisal. Sisal, a natural vegetable fiber, is only about one-half to one-fourth as expensive as glass. Even though the "as-compounded" cost differential may not be substantial by some standards—some sisal-reinforced compounds are only a few cents a pound cheaper than some low-glass compounds—it is enough to be significant in determining the feasibility of reinforced plastics for certain mass-produced parts.

Paralleling Woodall's development of premix molding, then, has been its development of a new engineering material. Sisal-polyester parts weigh less, have lower strength and are slightly more water-absorbent than glass-polyester parts. In general, sisal-polyester is used for functional, low-cost parts to be subjected to little stress. For more highly stressed parts or parts to be exposed to weathering or condensation, glass-polyester is preferred.

Applications

Sisal-polyester premix dates back about five or six years when



Loading the die . . .
Operator positions weighed charge of extruded premix (stacked at left).

. . . unloading the part.
Fiber reinforced polyester molding is ready for finishing and assembly.

it was first used for the housing of a rear window defroster fan, an auto accessory made by Eaton Mfg. Co. Now it is used for a variety of housings, panels and ducts, but the largest single application for sisal-polyester today is the heater housing and duct system for the 1955 Chrysler line.

This new heater-defroster unit was originally designed as a spot-welded steel assembly. It would have required 15 major stampings as well as more than 100 minor parts. Past experience had shown that such a design would raise troublesome problems in sealing and in assembly fitting. It was realized that many such difficulties could be eliminated by a combination of large plastic moldings. The problem was to develop a plastic molding that was economically competitive with a steel assembly, yet could withstand the heat and vibration encountered on the engine fire wall while supporting the weight of the heavy motor and fan.

As it turned out, a high-strength material was not necessary because section thickness had to be increased anyway to provide sufficient weight for sound deadening. The sisal-polyester design finally adopted consists of two large moldings that cover almost the entire width of the dash—one on each side of the fire wall. The 5.6-lb engine-side molding combines ductwork, the heater coil cover, and the fan and motor support. The 2.8-lb passenger-side molding consists entirely of ductwork.

According to A. J. Carter, of Chrysler Corp., the premix-molded heater housing has resulted in substantial savings due to 1) elimination of labor required to handle and spot weld a large number of stampings, 2) elimination of sealing at spot welded joints, 3) elimination of painting operations, and 4) absence of assembly problems created by poor-fitting parts. The integral design has also improved appearance and performance of the heater. Hot air temperature is 10 F above that in a steel housing because of the fewer seals required and the thermal insulation provided by the plastic.

In addition to heater housings and ducts, automotive parts being made of either sisal- or glass-reinforced polyester include seat sides and backs, arm rests, garnish moldings, door panels, air ducts and baffles, defroster nozzles, filter housings, radio speaker housings and air conditioner covers, pans and ducts. More than three million such parts have been produced in Woodall's Detroit plant.

Most of these parts have been fairly large and strictly functional; consequently most of them have been made in natural color or black and without further surface finishing. However, a number of parts have been painted or molded in color. In the future, Woodall engineers believe that painted premix moldings may well be competitive with painted die castings for smaller decorative parts.

Properties

By varying the formulation, it is possible to design premix materials with specific characteristics such as low moisture absorption, good color, high heat resistance, good electrical properties, high strength, good surface finish, short cure time, good flow, long shelf life or minimum cost. Physical properties of three low-cost materials used by Woodall are listed in the accompanying table.

An important limitation of present materials is their lack of uniformity. This lack of uniformity has been demonstrated by J. W. Greig, of Woodall Industries, as follows:

Test panels measuring 1/8 x 12

x 12 in. are molded under controlled conditions of time, temperature and pressure. Each panel is made with a single center charge. The molded panel is cut into about 14 test specimens as shown in Fig 1, and flexural strengths of these specimens are determined. High values reflect high fiber concentration plus favorable orientation of fibers. Low values reflect low fiber content plus unfavorable orientation of fibers.

Curve A is a typical frequency distribution of the flexural strength values obtained for a "low-strength compound". Curve B represents a typical "high-strength compound". Note the extreme breadth of this distribution. Similar results have been found with tensile and impact strengths. Curve C shows an "ideal" distribution that provides an intermediate, but dependable, design strength. This last curve represents the kind of material Woodall engineers would prefer to have, if possible.

Properties of premix-molded parts depend to a considerable extent on the flow of the compound during molding. In the test panel described above, flow is about as nearly ideal as can be anticipated for any commercial molding, i.e., virtually unimpeded. Ordinarily, however, the shape of the part causes interference with flow, resulting in a break in the front of the material as it flows through the die. When the two fronts created by a break flow together again they may form a visible "weld" line. This type of weld line marks a plane devoid of fiber reinforcement and hence a plane of weakness. An experienced molder, in cooperation with the part designer, can solve this problem through proper part and mold design, proper selection of material, and proper charging of of the mold.

Molding compounds

Woodall's premix molding compounds usually contain about 40% by weight of polyester resin. Fiber and filler contents vary depending on the application or on physical properties required. Reinforcing fibers are kept short to minimize fiber orientation and resulting planes of weakness. Fillers may include such common materials as calcium carbonate, aluminum silicate and asbestos. Compounds also contain pigments, a catalyst and an internal mold lubricant.

The processing characteristics of polyester resins make them particularly suitable for premix molding. They are clear liquids that can be furnished in various viscosities, and therefore no solvent is needed in their formulation. With a catalyst addition they can be rapidly converted to solids by controlled application of heat. Also, they do not give off any volatiles during cure.

Not all commercial polyesters can be used successfully. The resin must have a relatively flat viscosity-temperature curve, i.e., viscosity must not drop too sharply at elevated temperatures. Otherwise, the resin may be so fluid at the molding temperature that it will be squeezed out of the compound when the dies are fully closed, resulting in segregation of resin and filler. The resin used in Formadall materials is made by Rohm & Haas Co.

The premix compound may be prepared by weighing and blending fillers, fiber and other dry ingredients; weighing the resin and adding it to the dry blend; then blending dry and wet ingredients. The wet mixture is then either balled or extruded into sausage shapes. From these balls or sausages, individual charges are weighed for each press. Eventually, Woodall engineers hope to simplify the charging procedure by merely cutting the sausage into lengths of correct charge weight as it is extruded.

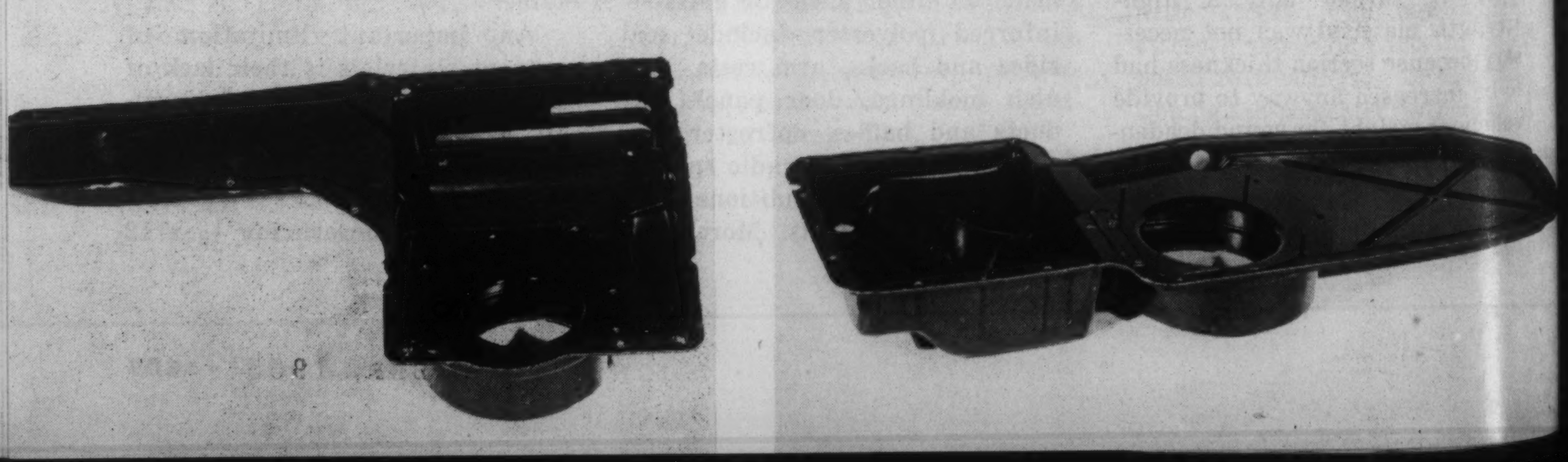
Molding process

The molding process is as follows:

1. One or more weighed charges of the putty-like molding compound are loaded on the lower of two hot matched-metal dies.
2. The matched dies are closed under pressure, forcing the compound to flow and fill all portions of the die cavity.
3. Pressure and temperature are maintained for a predetermined dwell time.
4. Dies are opened and the formed part removed hot. Usually the part is then placed in a cooling jig which may be mounted on a continuous belt conveyor.
5. The cooled part is removed from the jig, inspected and transported to the finishing department.
6. The part may then be subjected to certain mechanical finishing operations, fitted with various sub-assembly parts, and painted if necessary.

Proper placing of the charge is important. The charge must be placed in such a position that it

Heater housing and duct system *for Chrysler cars. Left, passenger side housing. Right, engine side housing.*



will flow to all parts of the die cavity under as low a pressure as possible. It must also be located in such a way as to minimize interference to flow by the shape of the die (as discussed above). For some large parts, two or three or more separate charges in different parts of the die cavity are necessary to insure proper flow.

Molding pressures range from 50 psi for a simple part to a maximum of about 800 psi. Most parts require pressures of at least 200 psi. The pressure required depends both on the flow characteristics of the molding compound and on the distance the material must flow (which is, in turn, a function of the size and shape of the part, and the number, size and location of the charges). Because molding pressures are low, even a 200-ton press, provided it has sufficient platen area, can easily handle extremely large moldings. Most of the presses now being used by Woodall are of this size, although some presses of up to 800 or 1000 tons are also being used.

Molding temperatures may range from 200 to 350 F, but the optimum range for high production appears to be about 290-320 F. Dies are heated by 150-lb steam.

Cure or dwell time may range from 30 sec to 2 min, depending on temperature and the thickness of the part. At a temperature within the 290-320 F range, dwell time for material up to about 1/8 in. thick is about 45-60 sec. Hourly production rate depends on many different factors, but 40-50 parts per hour is possible.

Die construction is conventional for compression molding (see Fig 2). For complex parts, the usual male and female dies may be supplemented by a laterally-operating cam or male punch. Pinch off edges are provided to trap the material in the die cavity. Dies are cast steel and surfaces are chromium plated to provide a good finish.

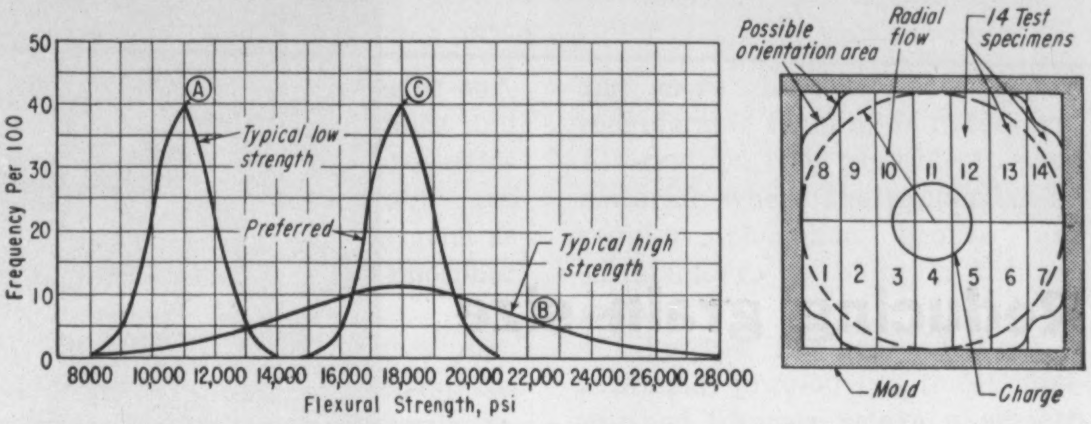


Fig. 1—Uniformity of premix-molded parts. Left, typical distributions of flexural strength values. Right, how specimens are selected.

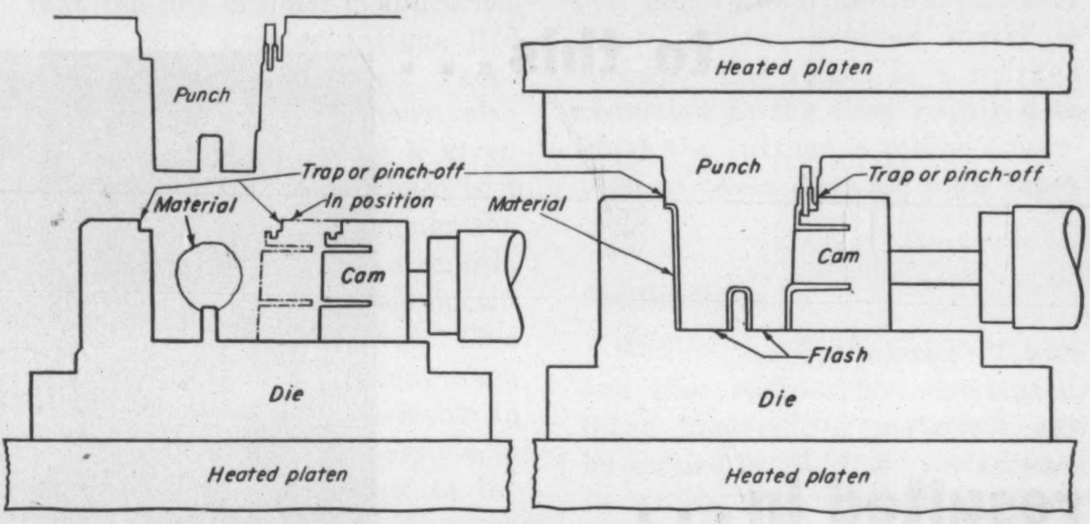


Fig 2—Die operation for premix molding.

TYPICAL PROPERTIES OF POLYESTER PREMIX MOLDINGS

Property	Test Method	Formadall 40 (sisal-reinforced)	Formadall 50 (sisal-reinforced)	Formadall 128 (glass-reinforced)
Specific gravity at 77 F	ASTM D 792-50	1.52-1.55	1.64-1.68	1.82-1.85
Flexural strength, psi	ASTM D 790-49T modified: 3/8 x 1½ x 8-in. specimen, 4-in. span.	4500-9000	5200-9100	9000-14,000
Modulus of elasticity in flexure, 10^5 psi	Same as above	6.5-8.5	7.5-9.5	9.0-1.05
Izod impact strength, ft-lb/in.	ASTM D 256-54T	1.5-3.8	1.8-3.5	2.3-4.0
Hardness, Rockwell M	ASTM D 785-51	35-60	35-60	64-80
Water absorption, % in 24 hr	ASTM D 570-54T	1.8-2.3	1.3-1.7	0.5-0.7
Thermal conductivity, Btu/sq ft/in./hr/F	ASTM C 177-45	—	1.8	1.4
Heat distortion temperature (at 265 psi)	ASTM D 648-45T	200-210	200-210	200-210

References

A. J. Carter, "Reinforced Plastic Heater Housings and Ducts", a paper presented at the SAE Golden Anniversary Summer Meeting, Atlantic City, N. J., June 15, 1955.

James W. Greig, "Matched Metal Die Molding of Premixed Reinforced Plastic Molding Compound", a paper presented at the SAE Golden Anniversary Summer Meeting, Atlantic City, N. J., June 15, 1955.

T. B. Merrill, Jr., "Automotive Materials Changes", *Materials & Methods* vol. 41, no. 1, Jan. 1955, p. 86.

Reducing grain size

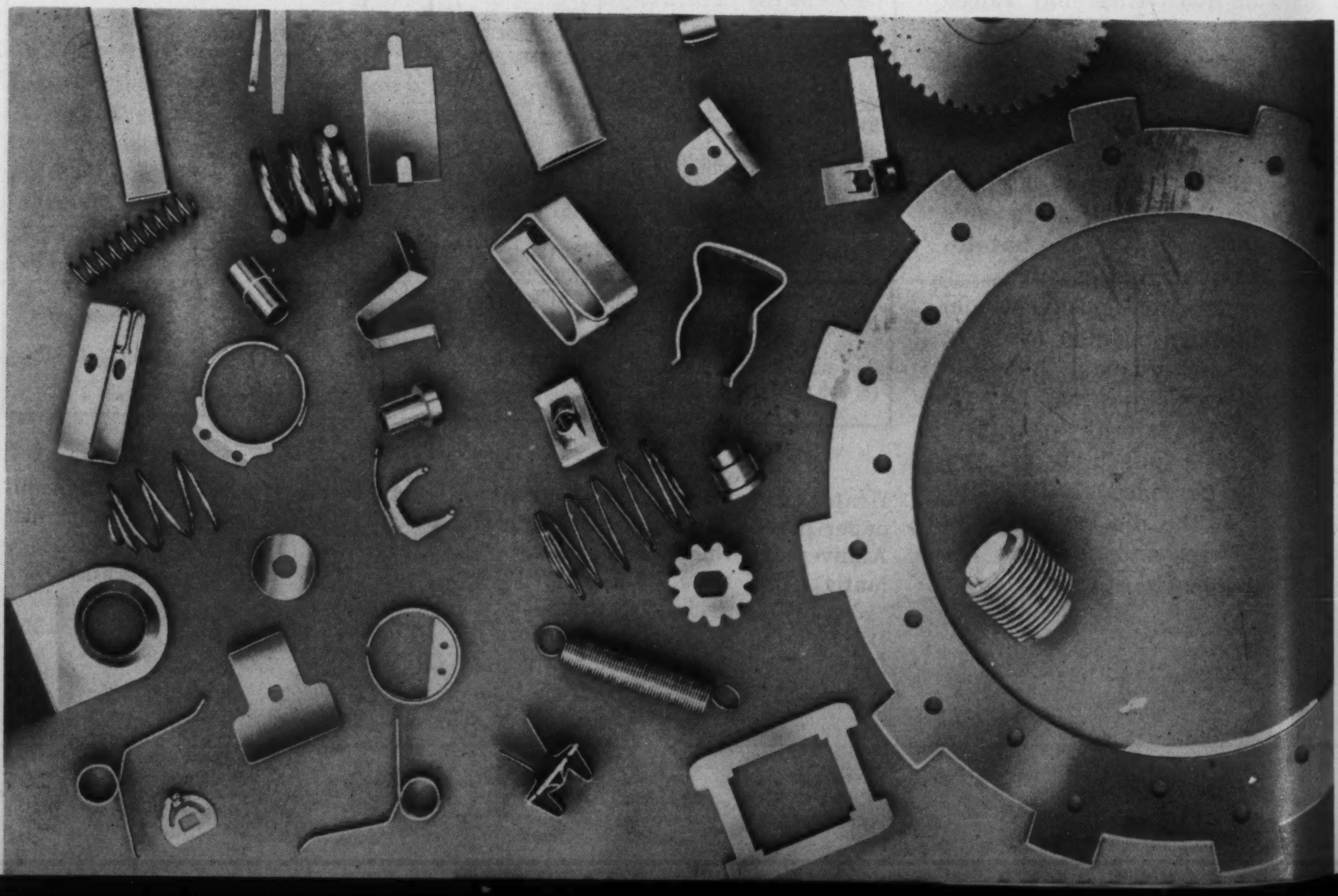
from this . . .

to this . . .

resulted in . . .

Fine Grained Phosphor Bronze

for applications like these . . .



■ Latest in the series of copper alloys available with extra-fine grain structure are the phosphor bronzes. Produced under the name Duraflex by the American Brass Co., these alloys are not new but are distinguished from the regular phosphor bronzes by their grain sizes.

The new fine-grained modification is available in the following standard phosphor bronze compositions: Grade A (5%), Grade C (8%) and Grade D (10%). These grades will be supplied in the tempers defined by the tensile properties in ASTM specification B-103 for strip and B-159 for wire. However, the procedure employed in producing the fine grained modification is applicable at present only to relatively thin material and the alloys are available only in sheet or strip up to 0.062 in. thick and in wire up to 3/16 in. in dia.

The most important production difference between the regular phosphor bronzes and the new product lies in the final anneal which is devised to yield a material with grain sizes no larger than 0.012 mm. As a result, Duraflex is said to have superior surface smoothness, appearance and hardness. Mechanical properties are also affected favorably and corrosion resistance is as good as that of the regular phosphor bronzes.

Resistance to fatigue is definitely improved by decreasing the grain size. Endurance limits determined on Grade A phosphor bronze in hard temper showed that the fine-grained modification had a 30% greater fatigue life than the regular product. Property improvement is shown also in the tensile test. For a given tensile strength range, there is a decided increase in the elongation with no sacrifice in yield strength.

Because of the increased ductility, formability is greater. This is particularly advantageous when increased strength is desirable in a product. Thus it is possible to form extra-hard Duraflex to the same degree which can be used in forming hard-temper ordinary phosphor bronze. Or spring temper fine-grained material can be used in place of extra-hard temper regular material. The result is the ability to produce harder and more durable parts where considerable forming is necessary. Alternately, it is possible to save material, where the properties of regular phosphor bronze are satisfactory, by using a thinner gage.

Like the fine-grained brasses available previously, these fine-grained bronzes retain a smooth surface finish after forming and do not show the familiar orange-peel effect which occurs frequently when coarser grained metal is formed. The result is a marked reduction in the time required to finish the surface, a major advantage in these days of high labor costs.

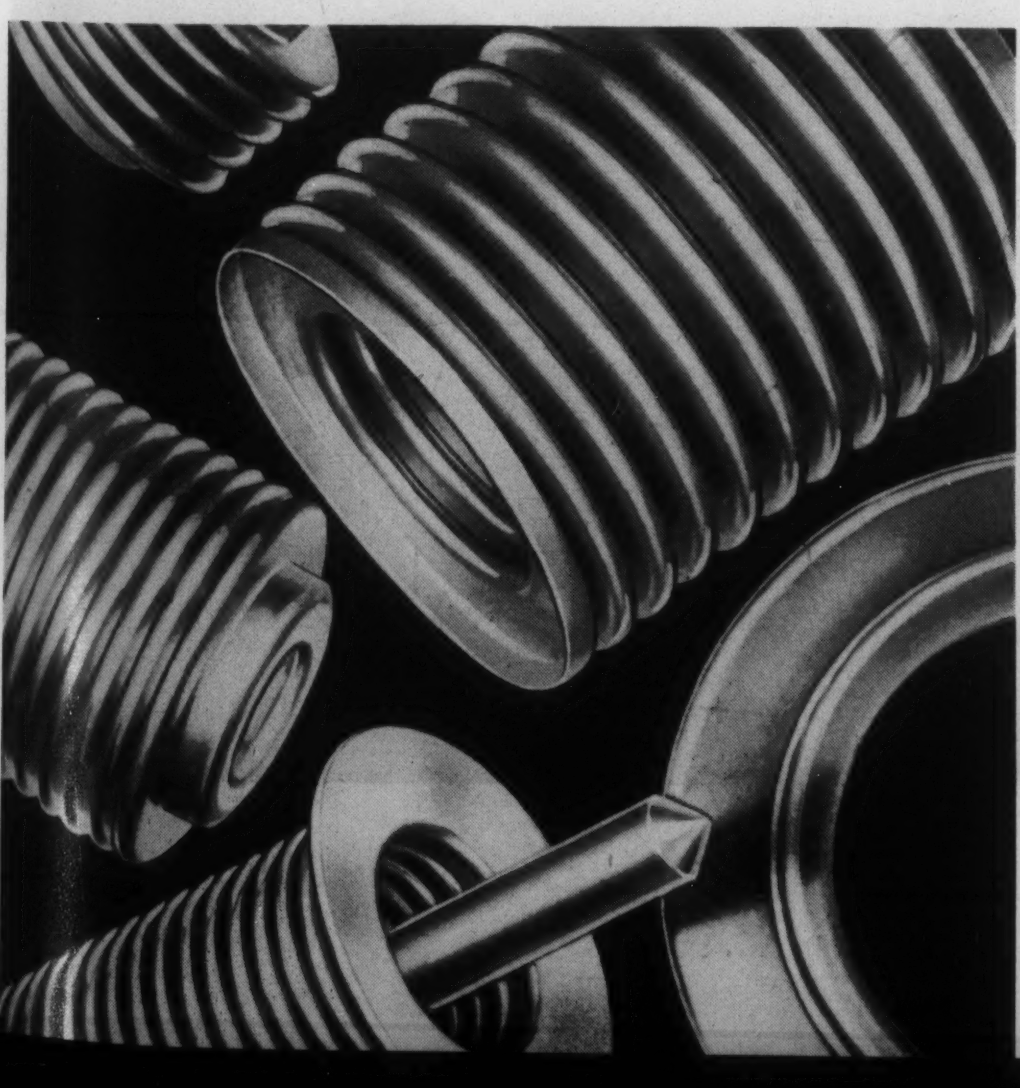
Applications

Within the limitations of size and alloy composition mentioned, these fine-grained materials can be applied in all of the varied uses in which the standard phosphor bronzes serve.

Because of their excellent elastic properties, the phosphor bronzes are used widely for springs. For flat springs Grade A and Grade C are used in the majority of applications. These include contact springs in communication and power transmission systems, spring-clip type binding posts, relay springs and clock springs to mention a few applications.

In wire form Grade A is used most widely, while Grades C and D serve for possibly 5% of applications. Wire is used for the production of tension, compression and torsion springs of many shapes and sizes. Wire serves also for the production of cotter pins, snap fasteners, wire rope, and electrical contacts.

Phosphor bronzes are used widely for bellows and diaphragms because of their excellent resistance to fatigue. Since surface smoothness improves fatigue resistance, the fine-grained materials should give superior service to the ordinary material in applications of this nature.

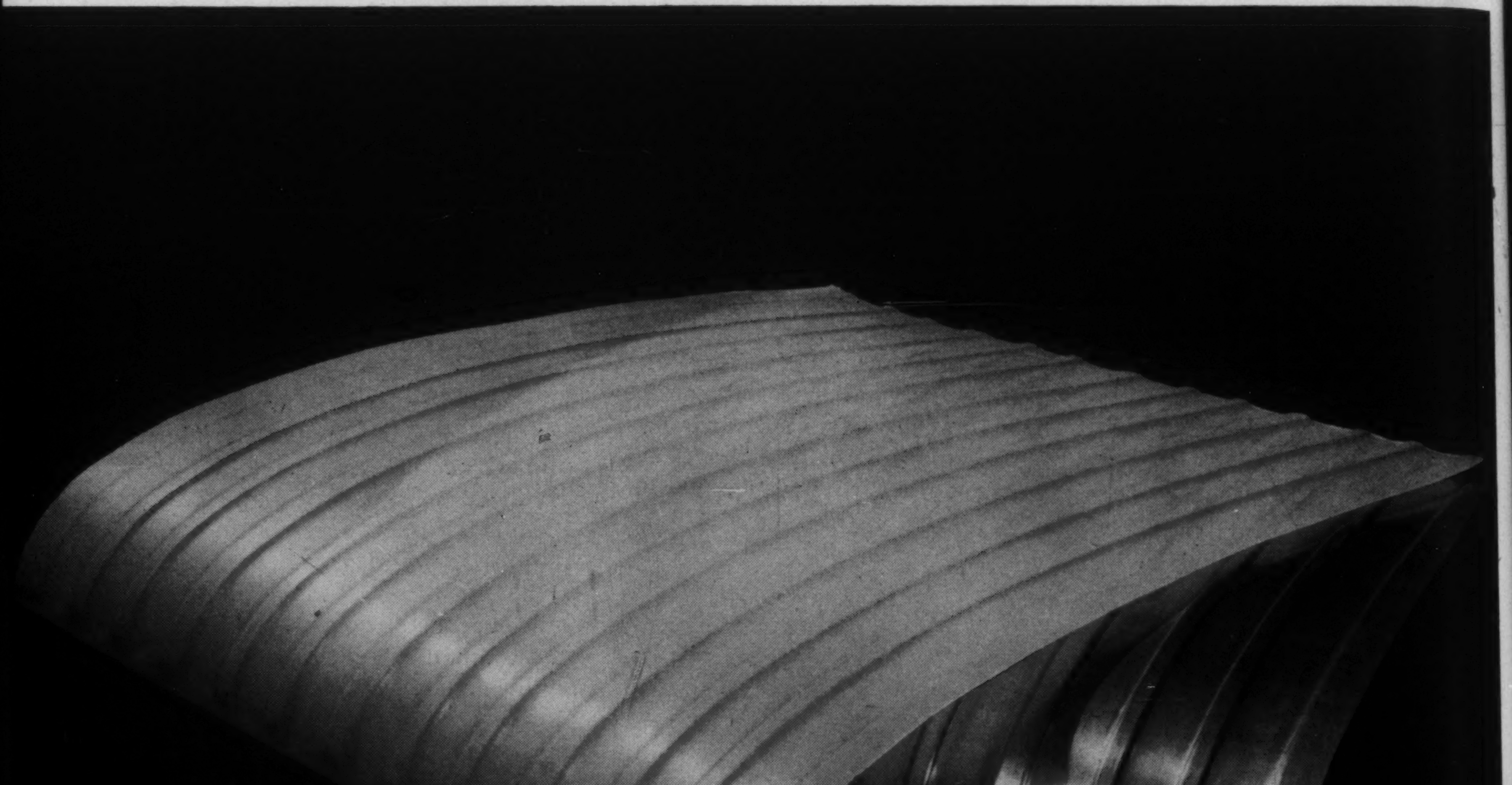


Silicone-Glass Parts by Vacuum Laminating

Here is an economical way of producing small quantities of oversize, complex or experimental parts without the expense of production molds.

by K. Hoffman and E. Elliott, *Product Engineering Laboratories, Dow Corning Corp.*

To make this part . . .



■ Vacuum laminating is usually associated with polyesters, but excellent glass-reinforced laminates for high temperature service can be made with certain silicone resins by taking into consideration a few basic differences in laminating properties:

1. Unlike polyesters which are used solvent-free, silicones must be applied to glass cloth in solution (as are phenolics), then precured to drive off the solvent and advance the resin to the laminating stage. The silicone laminating process is called "dry lay-up" to distinguish it from the "wet lay-up" techniques used with polyesters where resin is poured on glass cloth or mat right in the mold.

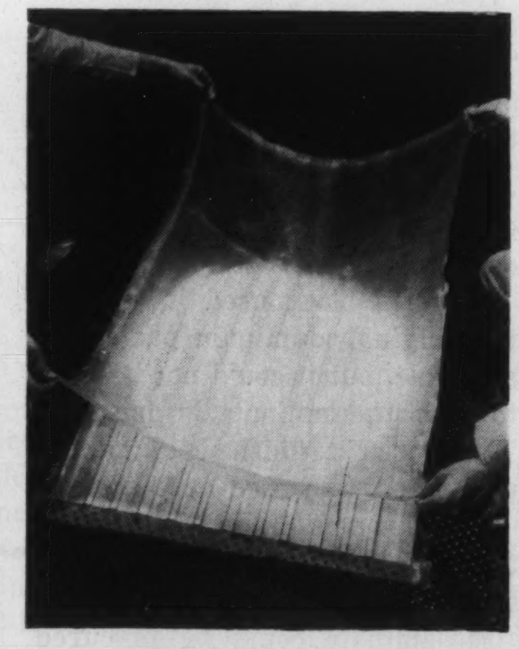
2. Viscosity of a silicone resin at its laminating temperature is about 10 times that of a polyester resin at *its* laminating temperature.

3. Like phenolics and ureas, the silicones are condensation resins and give off volatiles during cure.

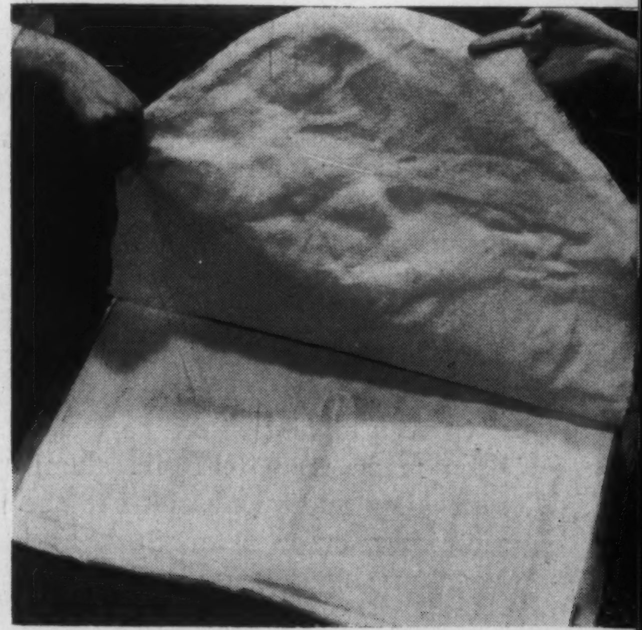
Vacuum laminating, also known as "contact", "bag" or "extreme low pressure" laminating, is a long and fairly complicated proc-

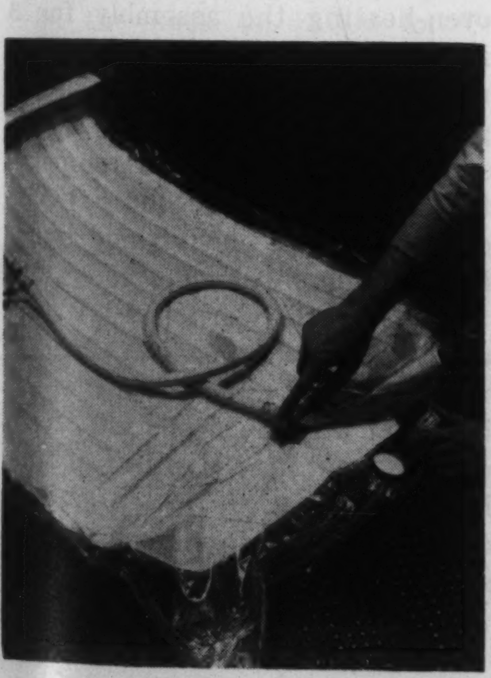
1 . . . *saturate cloth with resin*

2 . . . *lay it over the form, and precure*



3 . . . *add parting blanket and spacing cloth*





4 . . . *enclose entire assembly in bag, and evacuate*

5 . . . *smooth laminate, then give it preliminary cure*

6 . . . *strip off all coverings and give laminate final cure.*

ess compared to matched die molding. On a unit-cost basis, it is much more expensive than matched die molding for long runs. However, it offers a way to obtain a small quantity of parts, indistinguishable from those made in matched die presses, at a fraction of the cost of a single steel mold. As a result, vacuum laminating is becoming an increasingly popular method of producing a few oversize, complex or experimental parts without the expense of production molds.

A good example of a part that was vacuum-laminated with a silicone resin is an experimental section of the hot air duct to be used for wing anti-icing on the C-130 airplane being made by Lockheed Aircraft Corp. at Marietta, Ga. This part must withstand hot air temperatures of 400 F and higher. Its configuration includes a series of flat-bottom parallel channels for warm air flow, plus a compound curve. Fifty such parts will be used in each plane.

Conventionally, this part has been made from 0.016-in. aluminum alloy and spot welded to the aluminum outer skin. Such thin aluminum sheet is easily deformed and is therefore difficult and expensive to fabricate and assemble. A plastic laminate of equal thickness can be bent and bumped without permanent deformation. A silicone-glass laminate is lighter than aluminum (expected weight saving is 40 lb per plane) and has higher strength at elevated temperatures. Also, it is beieved that a laminate of the required stability will nevertheless be flexible enough to be expanded against the outer skin without need of further fastening.

Here is how this duct section was made by vacuum laminating prior to its recent acceptance as a production part:

1. Glass cloth was saturated with diluted resin.

If more than a dozen sample parts had been required, preformed and precured cloth would have been used. Here it was more economical to perform all production steps in a single cycle using the same mold.

Glass used was heat-cleaned 181-style cloth. Resin was catalyzed Dow Corning 2106, diluted with toluene to a viscosity of 7 sec on a Dow Corning No. 2 cup to provide a laminate containing 35% resin by weight.

In general, the lower the resin content (down to a certain point), the greater the strength and the elevated-temperature strength retention of a silicone-glass laminate. Best strength properties are usually obtained with this type of cloth and about 27-30% resin. The 35% resin content was selected for this part in order to allow for "flowout" during molding and avoid brittleness in the thin section.

2. Resin-soaked cloth was laid on the form and given a brief cure to drive off volatiles.

A form block used in making the original aluminum parts was available, but it could not be used to form the laminate in one step. Therefore, a finished aluminum part itself was used as the mold.

Precure was 4 min at 280 F in an air-circulating oven. Since there were only two plies, the entire laminate could be precured at one time. The resulting two-ply shape was similar to a preform.

3. A thin sheet of silicone rubber was laid over the preform, and coarse-weave glass cloth was wrapped loosely around the preform and mold to provide a spacing layer.

In vacuum laminating, the bag often tends to seal off the area around the valves before all air pockets elsewhere are evacuated. The coarse glass cloth layer tends to keep air passages open and thereby insure uniform pressure over the entire surface.

The rubber interleaving was used to keep the weave pattern of the spacing cloth from being impressed in the surface of the laminate. Heavy, heat-resistant cellophane was equally effective as a parting layer but made it difficult to obtain a wrinkle-free surface.

4. The entire assembly was enclosed in a plastic bag which was then evacuated by a rotary vacuum pump.

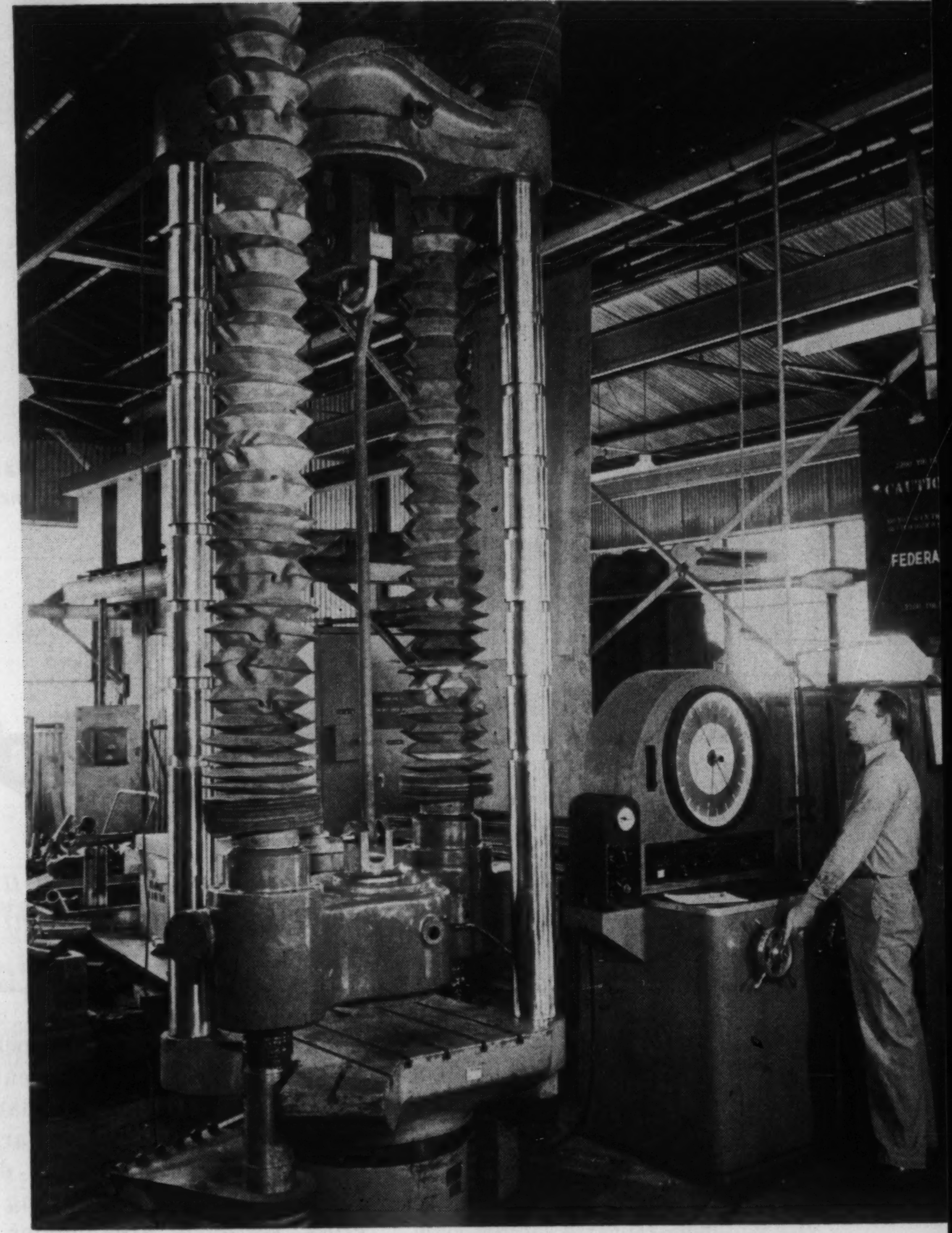
The bag was made by wrapping 20-mil polyvinyl alcohol film once around the assembly and heat sealing it. Bent-stem valves fitted with thin rubber gaskets were fastened to the bag at each end. The valves were connected to the pump by rubber tubing, and tube-valve joints were sealed with a high-vacuum grease. During evacuation the seal was carefully checked for possible leaks. The bag itself was straightened out and held as flat as possible to minimize air pockets and wrinkles.

5. With the vacuum still on, the entire assembly was subjected to a brief softening and burnishing treatment to smooth the laminate, then a 3-hr preliminary cure at 280 F.

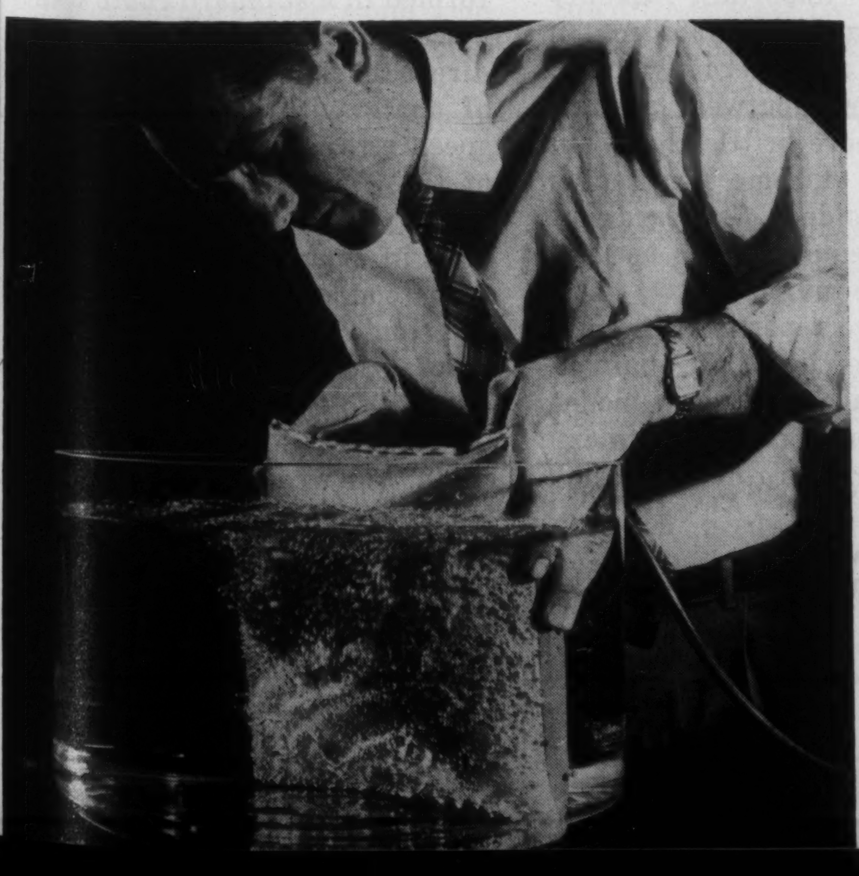
Although the plies were smoothed down as tightly as possible during evacuation, certain areas along the parallel ridges persisted in rising, showing traces of air bubbes. This springiness was at least partly due to the stiffness of the preform which tended to wall in entrapped air. These bubbles were removed by oven-heating the assembly for 3 min at 280 F, then burnishing rapidly. (This process can be repeated as many times as necessary provided the oven temperature does not exceed 300 F.) The oven was large enough and burnishing time short enough so that the men could work right in the oven.

When satisfactorily smooth the laminate was given a preliminary cure by heating the entire assembly—still under vacuum—for 3 hr at 280 F. The laminate was then strong enough to support its own weight.

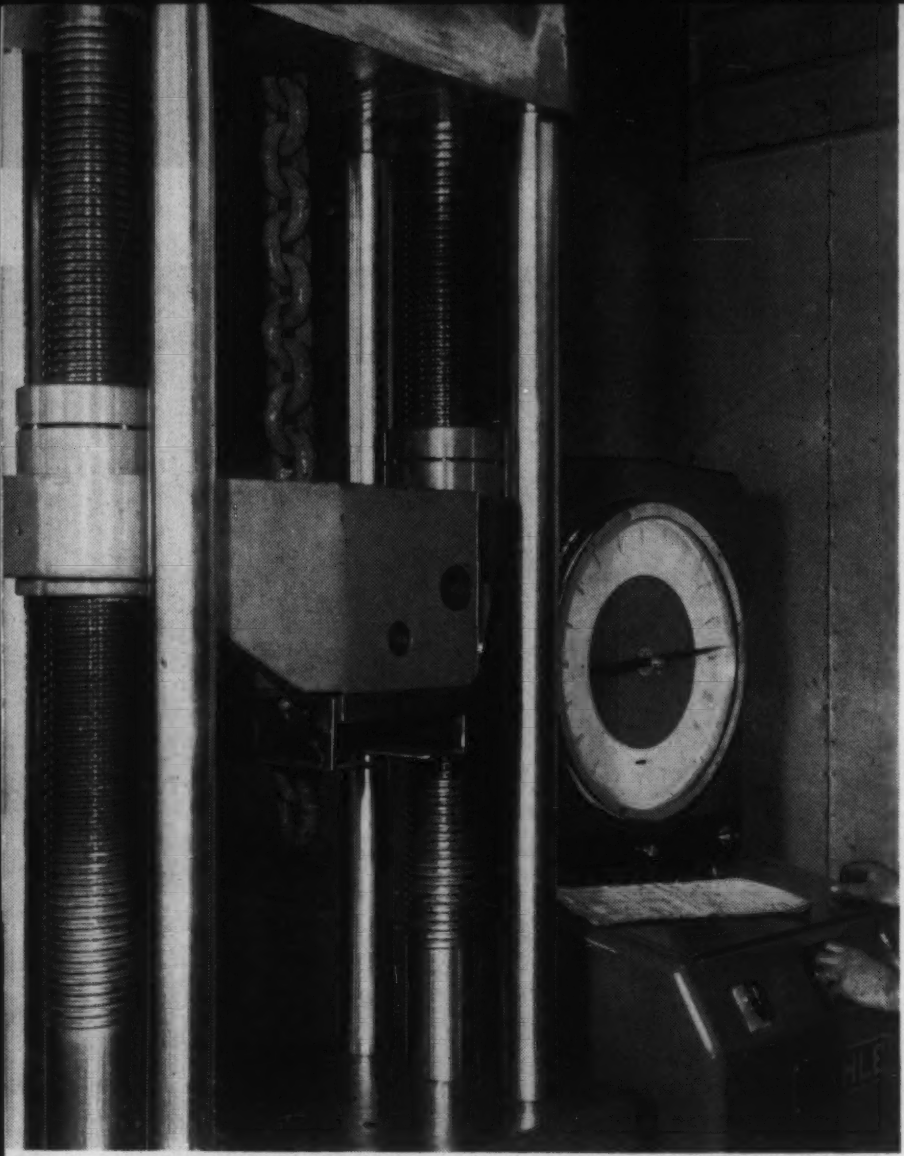
6. Bag, spacing cloth and parting blanket were stripped from the form, and the laminate—still on the form—was given a final 12-hr cure at 480 F.



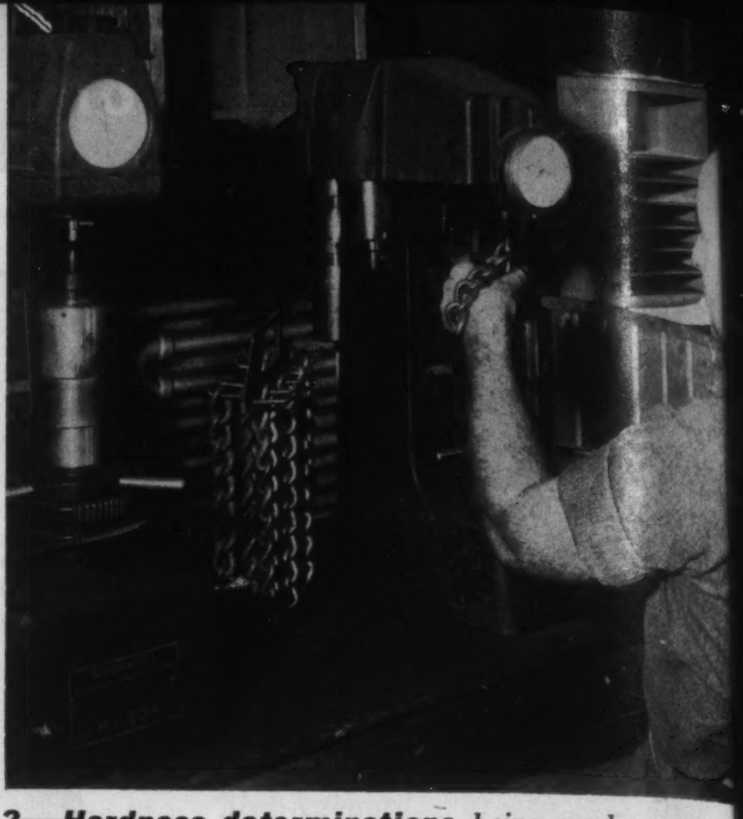
Proof Testing Steel Aircraft Hook Made of steel tubing with steel forgings flash-welded to each end, this 82-in. hook is designed to bring landing airplanes to a quick stop aboard aircraft carriers. It is here being proof-loaded in tension on a 440,000-lb Baldwin universal testing machine at Axelson Mfg. Co., Los Angeles. Tensile load on the hook is 62,000 lb. Tensile strength of the heat treated AISI A4340 steel used is 260,000 to 280,000 psi.



Porous Plastics Air bubbles burst from a pillow made of a new porous plastics material consisting of microscopic inter-connecting cells. Called Air-Porous Koroseal, the material is not perforated after forming, but is formed with a porous structure with approximately 50,000 cells per sq in. According to B. F. Goodrich, the cells act as "air conditioners" in allowing moisture vapor and air to permeate its surface. It is said to feel cool and fresh in summer heat, yet remain comfortable and pliable in winter temperatures. It can be applied to any type of fabric backing material including knit backs, sateen backs, broken twills and lightweight fabrics such as drills and sheetings. Soft and workable, it readily conforms to desired contours.



1—Tensile testing *a typical sample of chain in 300,000-lb capacity machine.*



2—Hardness determinations *being made on case-hardened cross chains for automobile tire chains.*

How Welded

Many different mechanical, metallurgical and nondestructive tests are used to assure top quality and uniformity of materials.

■ Both destructive and nondestructive testing techniques are employed to control quality and uniformity of materials in the welded chain produced in the York plant of the McKay Co. Destructive testing is used to establish the quality level of a representative number of samples from a batch-type operation such as heat treating. Nondestructive tests are applied to each link of certain basic types of welded chain to make certain that each foot of chain conforms to standards established by the Chain Institute, ASTM or other standardization groups.

Destructive testing

Destructive testing is used primarily to check the heat treatment used in the manufacture of the chain. Sample lengths are taken from each batch of chain from the heat treating furnaces and are tested to destruction to determine the yield strength, ultimate tensile strength and elongation.

Hardness of the chain during and after heat treatment is another important factor in chain quality control. Standard Rockwell and Brinell testing equipment are used. In the case of case-hardening, depth of the hardened area is of vital importance. This depth is measured by examining the cross sectional area under low magnification.

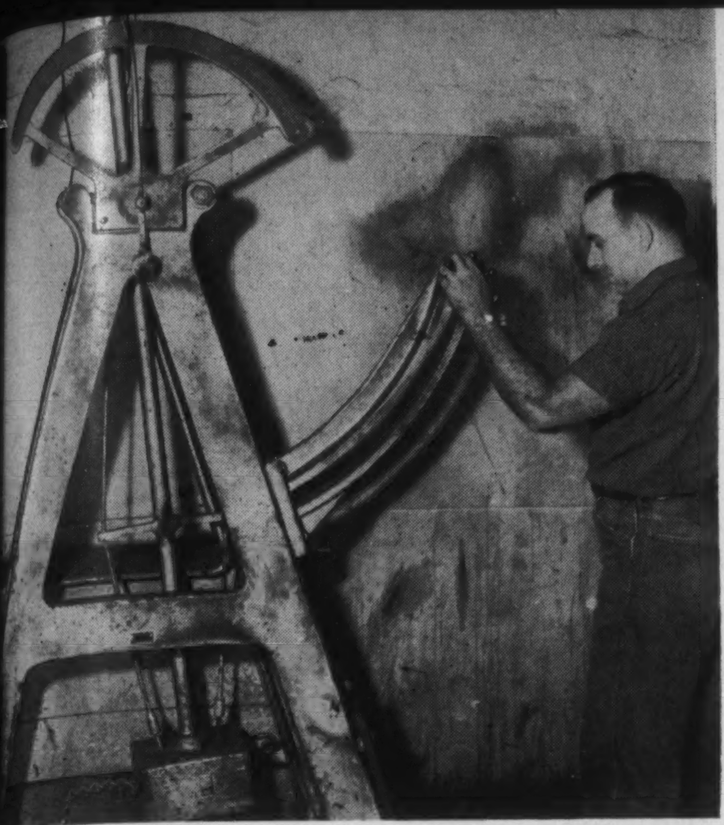
Toughness (impact resistance) is another important quality sought in chain manufacture. In many cases a moderately hard, tough chain will outwear a much harder but more brittle chain. In most cases, extreme brittleness should be avoided. Standard impact testing equipment is used to determine the toughness.

Quantitative reports on the mechanical properties of the chain or chain material often prove inadequate. It becomes necessary to examine the structure of the metal itself.

Nondestructive testing

The old adage that "A chain is no stronger than its weakest link" summarizes the inspection and testing problem confronting every chain manufacturer. Each link must be tested to insure its performance. Such 100% testing must not impair the usefulness of the chain or chain assembly.

The most common approach to the problem of 100% testing is proof testing. Proof testing is performed in a standard chain testing machine. The load is applied in direct tension to a straight length of chain with a uniform rate of speed represented by a separation of the tester heads not exceeding 10 in. per min. The test shows the load in pounds which the chain withstood in the condition and at the time it left the factory. The proof load for welded steel chain is equal to twice the recommended safe working load limit of the chain. For wrought iron chain, the proof load is approximately 15% greater than the recommended safe working load limits.



3—**Toughness is checked** *on standard impact testing equipment.*

4—**Metallographic examination** *of the effect of heat treatment on structure of an experimental chain material.*

by **H. F. Reid, Jr.,** *Manager, Technical Service Div., the McKay Co.*

Chain Is Tested

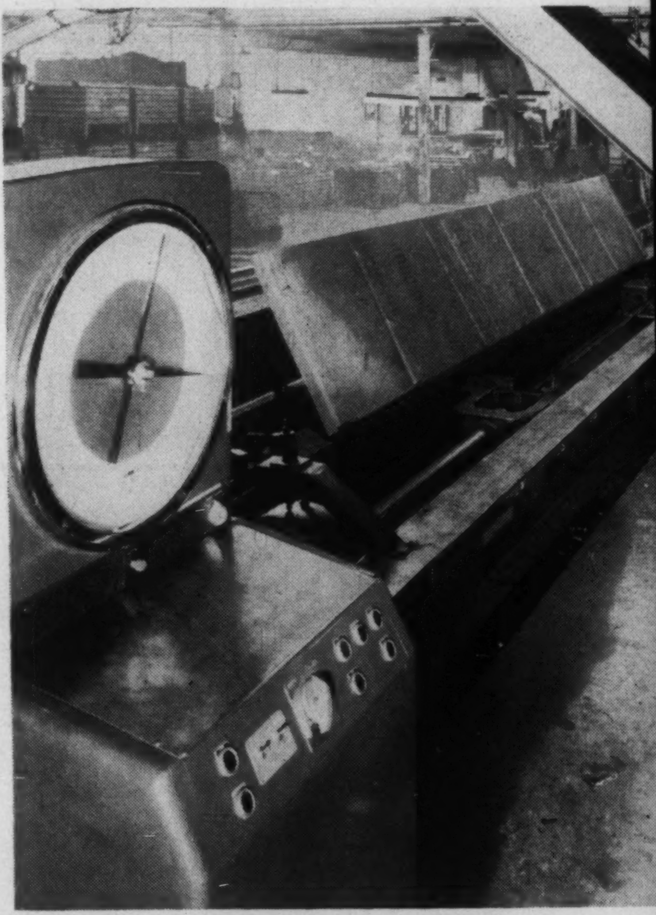
Most of the welding of chain is done by resistance welding. Electrical control devices are available to insure uniformity and reproducibility of the welding cycle. However, the master links and coupling links may be of greater diameter than can be welded in chain production equipment. Their various shapes and close hook-up further restrict the use of automatic welding equipment. At the McKay Co. such large size links are welded using atomic hydrogen techniques and filler metal of the same general composition as the base material.

In recent years there has been an increasing demand for radiographic examination of these manually welded areas, and the McKay Co. has installed a cobalt 60 source in a semi-permanent installation. Radiographs of master links and connecting links are being produced with greater than 2% sensitivity. Introduction of radiographic inspection procedures has resulted in modification and improvements in the manual welding operation.

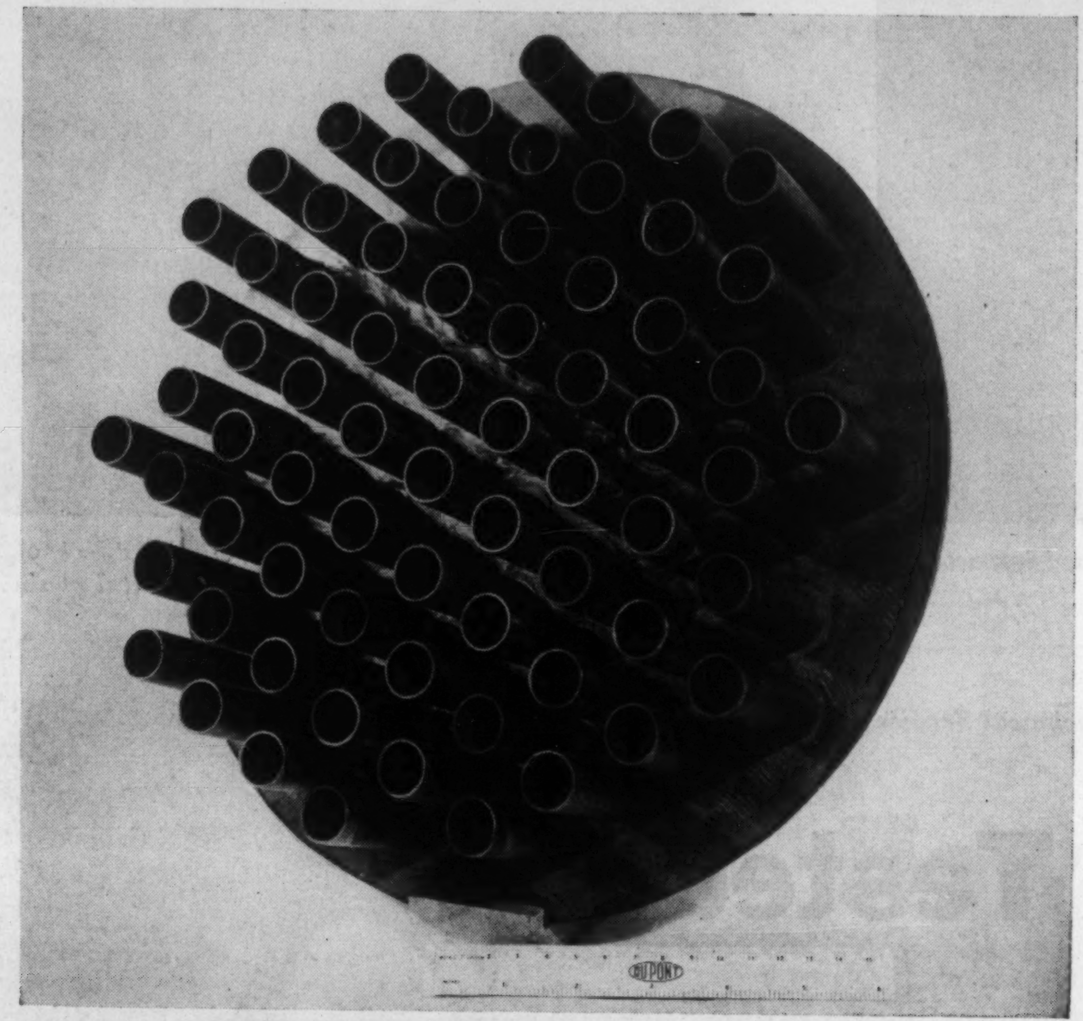
Future testing problems

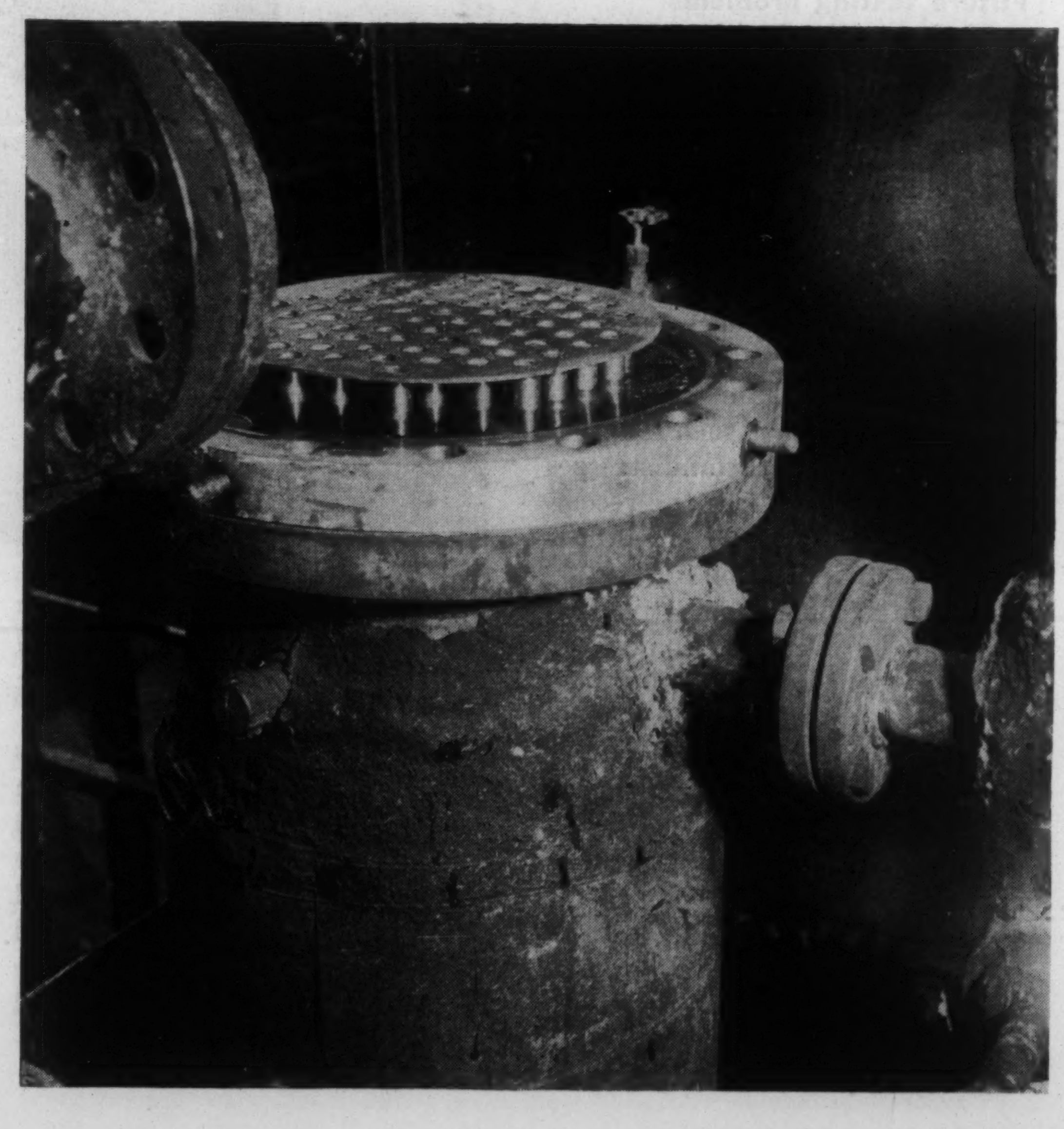
Chain testing, although thorough, has one major unsolved problem. The industry needs some method of detecting *that* individual link which can pass all proof testing and visual inspections, but which contains one or more internal flaws reducing its breaking strength below that normally expected for the particular type and size of chain. Proof testing guarantees that such a link of steel chain will withstand stresses equal to at least twice the recommended working load limit. It does not give any indication of the performance of such a defective link at loads of even 100 lb greater than the proof load. Locating such a single substandard link in a length of otherwise top-quality chain presents a challenging problem.

A satisfactory test procedure must of necessity be rapid and the answer clear cut. The testing equipment should be able to distinguish between surface voids, such as might be formed accidentally by a poorly trimmed weld flash, and subsurface imperfections in the weld area itself. Such a tester might become an integral part of each chain welder if the unit were compact, rugged and relatively inexpensive. Centralized plant testing probably would be adopted if the unit did not lend itself to individual machine installation.



5—**Proof testing** *on this 250,000-lb capacity machine is final check on large size sling chains. An 80,000-lb machine is used on smaller sizes.*

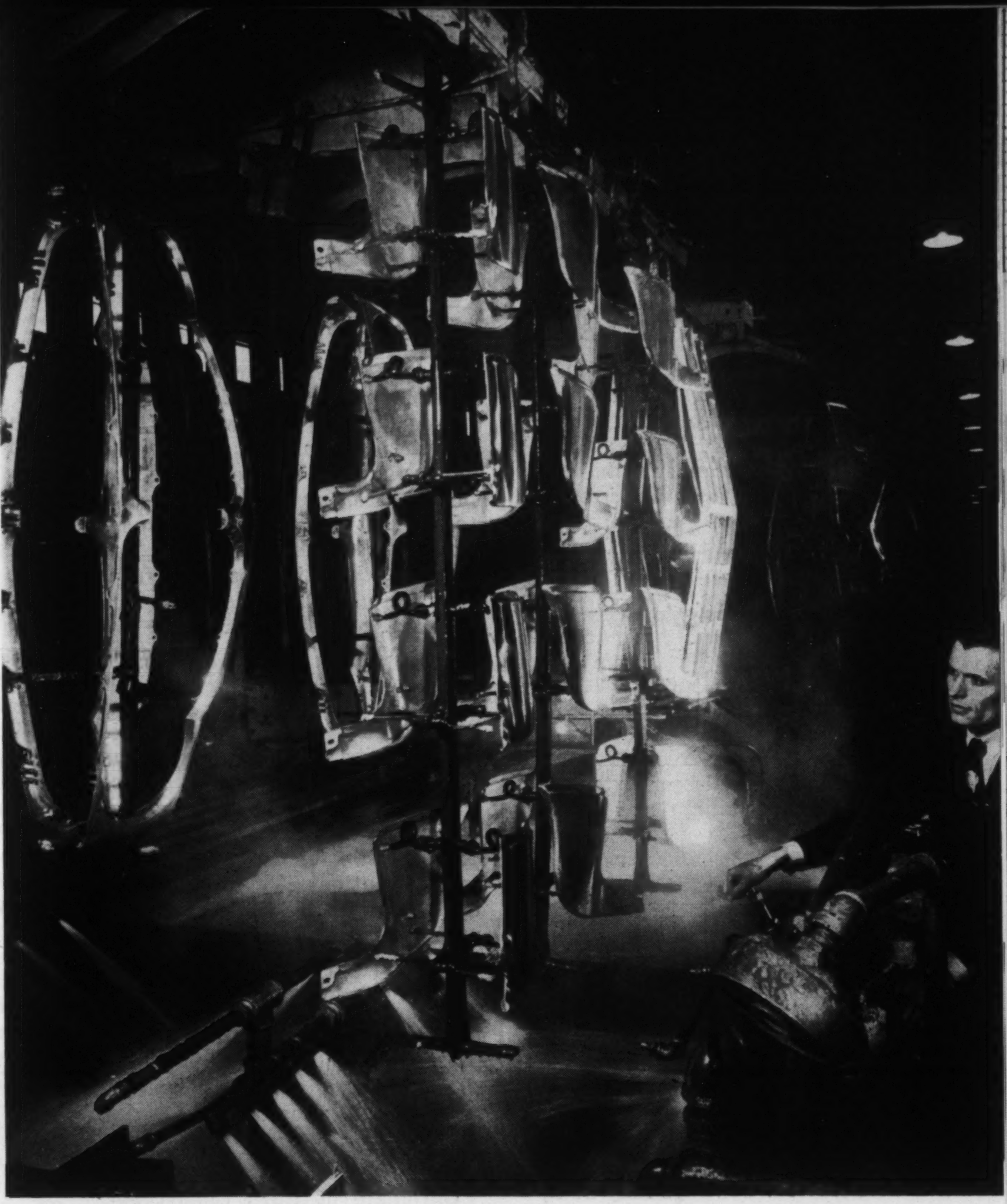




Titanium Stands the Gaff

Titanium "top hat insert" at top is shown after successfully withstanding 14-mo service in a condenser handling vapors of 60% nitric acid at 300 psi and 380 F temperatures. Shown at bottom, being placed in a condenser, the insert consists of 70 narrow titanium tubes welded to a round sheet of titanium. It is inserted in the tubes of the condenser to protect the most vulnerable part of the stainless steel assembly from severe corrosion by hot nitric acid. Performance of the titanium insert is said to be about 3 times more effective than stainless steel which has failed within 4-6 mo. The top hat insert was made with titanium produced by Rem-Cru Titanium, Inc., from DuPont sponge.

Chromium-plated *zinc die-cast radiator grilles for automobiles complete a multi-stage finishing cycle.*
(American Zinc Institute)



Finishes for Metal Products

—A Staff Report

MATERIALS & METHODS MANUAL No. 119

This is another in a series of comprehensive articles on engineering materials. These special sections provide the reader with useful data on characteristics and uses of materials, parts and finishes.

This manual outlines briefly the major types of permanent finishes that are applied to metal products. Since it does not give details on application, performance or cost, this manual cannot be used as the basis for final selection of a coating. It should, however, prove a useful starting point in the investigation of finishes likely to be suitable for a specific application. It covers:

- *Conversion coatings*
- *Organic coatings*
- *Metallic coatings*
- *Inorganic coatings*

Conversion Coatings

■ Conversion coatings are inorganic films produced by chemical reaction with the surface of the base metal. These integrally-bonded films vary widely in appearance, durability and cost. They may provide one or more of the following: 1) A decorative finish, 2) a protective barrier against corrosion, 3) an adherent base for an organic finish, 4) an adherent base for a lubricant, 5) a wear-resistant surface, 6) an electrically-resistant surface, or 7) a thermally-insulating or heat-reflecting surface.

Phosphate coatings

Phosphate coatings consist essentially of phosphate salts of the base or other metals. They are widely used on iron, steel and zinc, and, to a lesser extent, on aluminum, cadmium and tin.

These coatings are used chiefly as a paint base. The relatively porous surface of the film provides excellent paint adhesion, and the phosphate barrier, even when penetrated, prevents under-film corrosion. Phosphate coatings are also used as a base for protective or lubricating oils and waxes.

Phosphate coatings are applied by bringing the base metal into contact with aqueous solutions containing phosphate salts, phosphoric acid and various reaction accelerators. Coatings may be applied by immersion, spraying, brushing or swabbing. Many different proprietary processes are available.

Paint-base coatings for iron and steel consist of thin, dense, crystalline zinc-iron or manganese-iron phosphates. Coatings of 100-600 mg per sq ft are applied within a few minutes from accelerated solutions at room temperatures. Coatings are often improved by a dilute chromic acid rinse. Typical applications are auto bodies and refrigerator cabinets.

Oil- or wax-base coatings for iron and steel consist of thick, porous, crystalline manganese-iron phosphates. Coatings of 1000-4000 mg per sq ft are applied in less than an hour in hot baths. Oil-sealed coatings are used to lubricate such parts as auto camshafts, rocker arms, valves, tappets and piston rings. They are also used to protect hardware and firearms.

Paint-base coatings for zinc and cadmium, as well as zinc- and cadmium-coated metals, consist of thin, dense, crystalline zinc phosphate. Coatings of 75-500 mg per sq ft are applied within a few minutes from hot solutions. Where zinc is to be painted, a phospate coating is often needed to prevent an undesirable reaction between the metal and the paint. A thin zinc coating plus a phosphate coating also provides an excellent base for paint on steel where good protection against atmospheric corrosion is needed.

Paint-base coatings for aluminum and its alloys consist of aluminum and chromic phosphates. Thin, hard, amorphous coatings of 100-200 mg per sq ft are applied within two minutes from warm solutions. Typical applications are trailers, aircraft and washing machine tubs.

A complex but easily-applied phosphate-oxide coating is available for tin. The invisible film is used on tinplate for atmospheric protection and to prevent unsightly blackening caused by sulfur-containing foods.

Chromate coatings

Chromate coatings consist essentially of insoluble trivalent chromium compounds and somewhat soluble hexavalent chromium compounds. They are used on zinc, zinc- and cadmium-coated metals, aluminum and magnesium.

These coatings are generally less than 0.02 mils thick and are used chiefly for corrosion resistance. Unlike most phosphate coatings, chromate films are amorphous and nonporous. The film itself is a barrier to moisture and tends to be self-healing, and the slightly soluble hexavalent chromium acts as a corrosion inhibitor. Chromate coatings have relatively low resistance to abrasion and heat. They also have low electrical resistance. They are sometimes used as a base for organic coatings.

Coatings for zinc and zinc- and cadmium-coated metals are usually applied in less than a minute from room-temperature acid dichromate solutions. Typical applications are hardware, carburetor bowls, and ordnance equipment. Two types of thin, bright films can be obtained: yellow iridescent and clear. Clear films are obtained by bleaching hexavalent chromium from the original film. They are not as effective as the yellow films and are often protected with a clear lacquer. Heavier, matte films of yellow, bronze, black, and olive drab (the most durable and protective) coatings can also be obtained. By immersion in acidified organic dyes, they can be converted to a great variety of deep and pastel colors, including red, orange, green, blue, violet and black.

Chromate coatings for aluminum are relatively recent. They can be applied in a few minutes from room-temperature or warm solutions by immersion, spraying, brushing or swabbing. Thin films are clear; thicker films may be iridescent yellow or brown. Some films can be dyed in various pastel colors. Chromate coatings are more corrosion-protective and less expensive than anodic films, they seem to provide an equal or better paint base, and they can be applied to aluminum-silicon alloys. However, they are much less wear-resistant than anodic films. Sometimes they are applied over anodic films where resistance to both wear and corrosion is required.

A variety of chromate immersion processes are used for magnesium and its alloys. A coating (Dow No. 1 or "chrome pickle") produced by brief immersion in a room-temperature acid dichromate bath is used for temporary protection or as a paint base where dimensional tolerances are not close. For greater corrosion protection, this film can be sealed by a 30-min immersion in boiling dichromate solution (Dow No. 10 or "sealed chrome pickle"). A brown-to-black coating (Dow No. 7 or "dichromate") that provides excellent corrosion protection and a good paint base with minimum dimensional change on most alloys is produced by a brief hydrofluoric acid dip, followed by 30 min in a boiling dichromate-fluoride solution. A more abrasion-resistant, dark grey-to-black film (Dow No. 8 or "alkaline dichromate") is produced by a similar process utilizing a boiling alkaline dichromate-sulfate solution. A black film (Dow No. 9 or "galvanic anodize") similar to the dichromate film can be obtained by a brief hydrofluoric acid dip, followed by galvanic immersion (the magnesium is electrically connected to steel tank or cathode) in a hot alkaline dichromate-sulfate solution for 20 min. A decorative but not too protective black finish (Dow No. 4 or "chrome-alum") for die castings is produced by immersion in boiling dichromate-chrome-alum solution for several minutes. A recently developed proprietary coating claimed to be at least equally protective and more deformable than the dichromate film, can be applied from a room temperature solution by dipping or brushing in less than 2 min. Color varies from light to dark brown. Many other processes are used occasionally to provide bright decorative coatings, protective or paint-base films, or low-electrical-resistance films.

Other chemical coatings

Other chemical conversion coatings are often used on iron, steel, stainless steel, copper and its alloys and aluminum and its alloys. These coatings vary widely in actual composition, but most of them are produced by exposing the base metal to hot, oxidizing solutions or gases. They are usually quite thin (0.02-0.2 mils), and many of them have characteristic colors. These coatings may be used for decoration, for corrosion protection, or as a paint base.

Thin, black oxide coatings are obtained on ordinary steels by immersion for several minutes in a hot (about 300 F), strongly alkaline solution. These coatings have good resistance to abrasion and chipping, and they are suitable for stressed or close-tolerance parts. They are not protective and are usually sealed with oil or wax; they may also serve as a base for paint. On stainless steel, black oxide coatings are produced by immersion in fused dichromate (about 740 F). A number of proprietary processes for steels are available. Typical applications are hardware, machine parts, firearms and tools.

Oxide films of various colors ("heat tints") ranging from straw yellow to light blue are produced by heating steel in air at various temperatures from 400 to 640 F for controlled periods of time. A black "gun-metal" finish that can be oiled is produced by heating steel with carbon and oil at temperatures in the 650-750 F range. A blue film with good electrical resistance is produced on silicon steels used for core laminations by exposure to 930 F steam. A bright copper-like film is produced by brief immersion in proprietary, hot acidic solutions. A brown color is produced by a complex procedure utilizing a browning solution and induced rusting.

Paint-base films for copper and its alloys are produced by brief immersion in hot, oxidizing caustic solutions. Many standard and proprietary dip processes are available for blackening or coloring copper and brass. These films are usually protected with a clear lacquer or varnish. Typical applications are hardware, jewelry, lamps, statuary and architectural trim.

On both copper and brass, coatings ranging from light brown to black, depending on time and temperature, are produced by brief immersion in alkaline sulfide solutions; and "antique green" films are applied from a complex ammoniacal solution by dipping or brushing, followed by stippling.

On copper, a "steel black" finish is produced by immersion in a hot, acidic, arsenious oxide solution; a blue-green finish by repeated spraying of an ammoniacal sulfate solution, followed by exposure to moisture; and a dark red film by immersion in molten potassium nitrate (about 1250 F), followed by buffing.

On brass, a blue-black finish is produced by brief immersion in a hot, ammoniacal carbonate solution; a statuary bronze film by a similar process plus an acid dip; gold or light green films by immersion in acid bichromate solutions; and a green film by immersion in a hot, iron nitrate-hyposulfite solution. Brass parts are sometimes plated with a copper flash, then colored by processes suitable for copper.

***Bright chromate** film is combined with a zinc electroplate on these steel parts.* *(Allied Research Products, Inc.)*

***Black anodized** film and baked wrinkle enamel minimize undesirable reflections and provide both a grippable surface and a pleasing appearance for these light-weight aluminum binoculars.*
(Aluminum Co. of America)

Paint-base coatings for aluminum are produced by immersion for 10-20 min in a warm, alkaline dichromate-carbonate solution. These films give better corrosion protection when sealed by immersion in a boiling, dilute dichromate solution. They can be dyed, but colors are not too satisfactory. A frosty, white satin finish, often used on refrigerator trays, is produced by various alkali or acid etching treatments. It is generally protected by a clear lacquer or by subsequent anodizing. A black film is produced by immersion in an alkaline arsenic solution; and white or green-white decorative films by immersion in a hot alkaline sulfate solution, followed by heating to 390 F.

A number of proprietary blackening processes are also available for zinc, cadmium, and zinc- and cadmium-coated metals. Typical applications are hardware, tools and gasoline drums.

Anodic coatings

Oxide or hydrated oxide coatings can be applied to aluminum, magnesium and their alloys by various electrolytic immersion processes in which the base metal is connected as an anode. These films range widely in thickness and may provide wear resistance, corrosion protection, electrical insulation, heat insulation, or a base for paint or dye.

Anodic coatings on aluminum are usually applied by a sulfuric acid process operated at moderate temperatures and current densities. By proper control, grey films having a wide range of thickness and hardness can be obtained in less than an hour. Dimensional change is about one-third total film thickness. These films are usually "sealed" by immersion in boiling water or steam (for a period equal to that of the electrolytic treatment) to partially convert the oxide to the more voluminous monohydrate and thereby reduce porosity. For better corrosion protection, these films may be sealed by immersion in hot dichromate or silicate solutions. They may also be painted, or impregnated with oils or waxes. Hard, dense films about 0.2-0.4 mils thick are used where normal corrosion protection and wear resistance are required. Excellent colored coatings are obtained by producing a relatively soft, porous film; coloring it either by immersion in warm dye solutions or by chemical precipitation of mineral pigments in the pores; then sealing the film by immersion in hot water or dilute nickel acetate. Typical applications are trains, ships, refrigerator ice trays, window frames and store fronts.

Other processes are sometimes used for aluminum. Light grey-to-black films (about 0.1-0.2 in.) applied by a chromic acid process are relatively soft but provide optimum corrosion protection and are used on aircraft. Moderately hard, abrasion-resistant films up to 1 mil thick are provided by an oxalic acid process; these films are golden yellow and often transparent. Films that have good electrical resistance and can be dyed are produced by a sulfamic acid process. A thin, hard, nonporous film used on electrolytic condensers and rectifiers is produced in a boric acid-borate bath that, unlike the other processes, exerts no solvent action during film formation.

Exceptionally thick (1-10 mils) anodic coatings are applied to aluminum where good wear resistance, electrical resistance or heat resistance is required. Proprietary "hard coat" processes utilize acid electrolytes operating at low temperatures (0–35 F). Typical applications are pistons, valves, cams, brake disks and computer gears.

A number of anodic coatings are applied to magnesium and its alloys. Hard, light grey-to-light tan films (Dow No. 12) are produced on all alloys by a.c. or d.c. immersion in a hot alkaline diethylene glycol solution for 20 min. These films can be dyed. Hard grey anodic films are also produced by a proprietary process consisting of a.c. or d.c. immersion in a hot alkaline silicate bath for 25 min. The a.c. film is dark grey, about 0.4 mil thick and is applied to light wrought products of all alloys. The d.c. film is light grey, about 0.8 mil thick and is applied to castings of most alloys. Both films can be dyed. A hard, abrasion-resistant coating (Dow No. 14) ranging from grey to white in color and having good defect-covering power can be obtained by continuously increasing the voltage to a relatively high level in a room-temperature borate-silicate bath for 15 min. All of these films may be waxed. When any of them are used as paint bases, they are usually first neutralized and/or sealed by immersion in dichromate solutions.

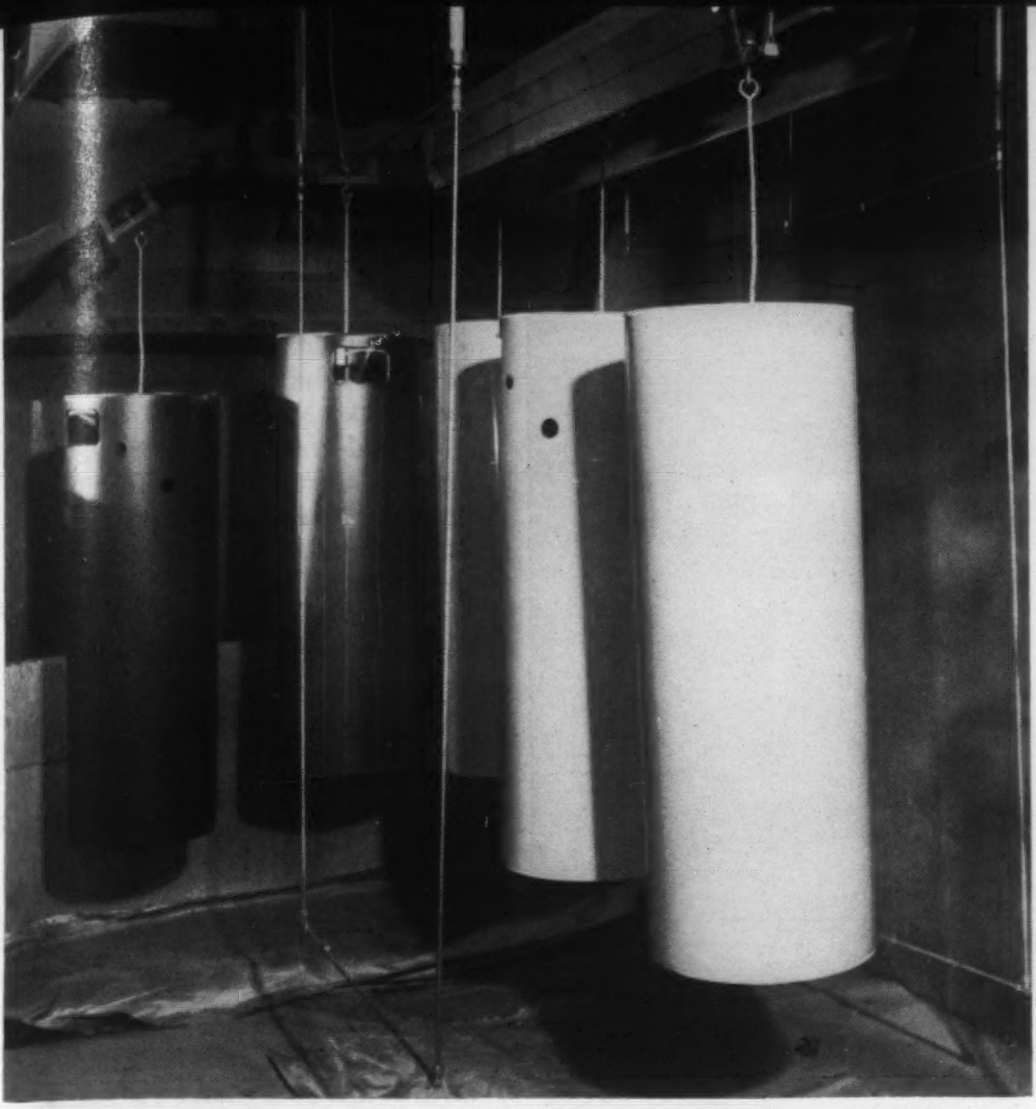
Recently, two methods for applying coatings of a ceramic nature to magnesium have been developed. The "HAE" coating, produced in a complex alkaline bath, is about 1 mil thick, provides excellent wear resistance and heat resistance, and is a good paint-base. Sealed with wax, a zinc chromate primer or a phenolic varnish, it provides exceptionally good corrosion protection. Since it is quite brittle and easily cracked or chipped, however, it may prove to be largely restricted to castings. Coatings produced by the other process ("Dow No. 17") range from 0.2 to 1 mil in thickness (light to dark green in color). Thin films are used on sheet and thicker films on castings and other rigid sections. Dimensional change is about two-thirds of total film thickness. Although the film is brittle and susceptible to cracking, a chromate film produced by the acidic dichromate-fluoride bath acts as a corrosion inhibitor. These films, like HAE films, are usually sealed for optimum corrosion protection.

Other anodic coatings include a black finish for brass, and yellow, black and clear (bleached) films for zinc. Decorative cathodic films can be applied to most common metals by a proprietary process. Colors vary with film thickness and cover the entire spectrum. These films are protected by a clear lacquer.

Organic Coatings

Organic coatings may provide one or more of the following: 1) A decorative finish, 2) a protective barrier against corrosion, 3) an electrically-insulating barrier, 4) a lubricating surface, 5) a protective barrier against high-temperature oxidation, or 6) a non-skid surface. They are sometimes applied directly to the base metal, and sometimes applied over a conversion or metallic coating where better adhesion or better corrosion protection is desired.

Some organic coatings are monolithic, e.g., sheet, film, tape, hot melt coatings and many clear lacquers and varnishes. However, the most commonly used organic coatings consist of two or more layers. The first layer is a primer coat, formulated to combine good adhesion to the metal surface and good compatibility with the second coat.



***Alkyd-amine baking enamel** is electrostatically sprayed on water heater jackets.* *(The Sherwin-Williams Co.)*

Where corrosion protection is important, it also incorporates a corrosion-inhibiting pigment such as red lead, zinc dust or zinc chromate. The second or top layer is formulated to provide whatever combination of opacity, reflectance, color, texture, mechanical strength, abrasion resistance, chemical resistance, weather resistance or heat resistance is required for the specific application.

Organic coatings used on most metal products are 0.2-2 mils thick. Coatings of at least 5-6 mils, applied in at least three layers to minimize porosity, are recommended for protection against corrosive atmospheres or fumes. Protection against concentrated chemical fumes or splash usually requires coatings more than 10 mils thick. These "mastics" consist either of high-build lacquers or varnishes or of hot melt coatings, and may be as much as 1/16 in. thick. Sheet or films are ordinarily used where heavier coatings ("linings") are required or where immersion in chemicals is involved.

Lacquers, varnishes and enamels are available in many different formulations. They vary not only according to film properties and drying characteristics ("air-drying" or "baking"), but also according to method of application. The most common methods are brushing, dipping, roller-coating, spraying and flow-coating. In recent years, new techniques such as hot spraying, steam spraying and electrostatic spraying have reduced the cost and stimulated ever-wider use of sprayed coatings. Still more recently, the development of advanced flow-coating techniques has resulted in expanding use of higher-build, more uniform and less porous flow coatings in preference to sprayed coatings.

Sheet and strip of many different metals precoated with a variety of organic finishes are commercially available.

Oil paints

An oil paint is a dispersion of one or more pigments in a vehicle consisting essentially of a drying oil and a solvent thinner. When it is applied to a metal surface, usually by brushing or spraying, the thinner evaporates and the drying oil slowly oxidizes (more rapidly with driers) to form a dry, pigmented film.

Drying time, hardness and elasticity of these paint films depends to a great extent on the drying oil or combination of drying oils used. Linseed and soybean oils dry slowly and form flexible films. Tung and castor oils dry more rapidly and form harder films. Less widely used oils include perilla, oiticica, tall, fish and synthetic-modified oils.

Compared with synthetic resin-base coatings, oil paint films are generally softer, more flexible, less glossy and less chemical-resistant. Today, because of the availability of organic coatings that dry faster and have better film properties, oil paints are seldom used on metal products. They are used primarily on large fixed structures such as bridges, oil storage tanks and water towers.

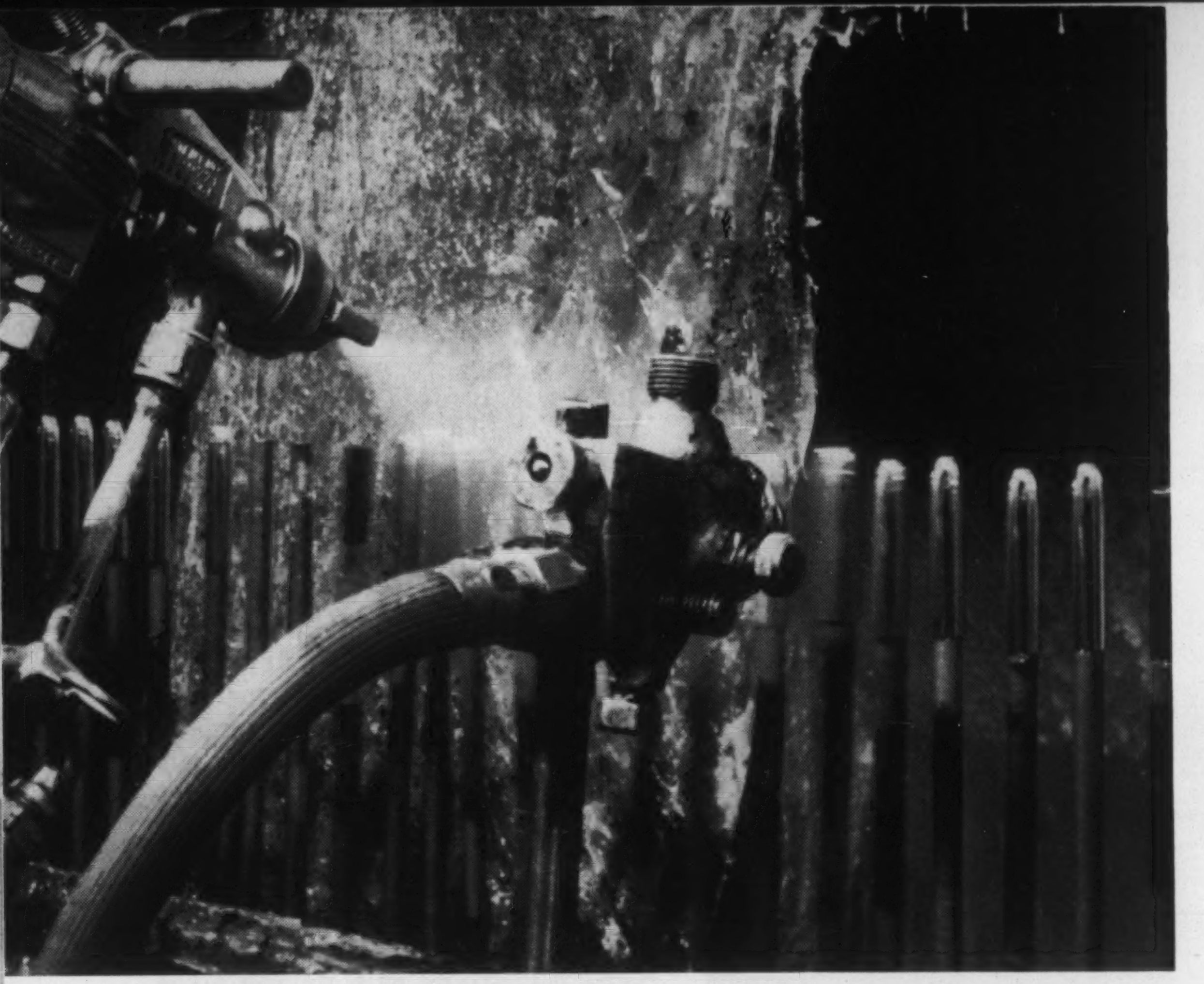
Varnishes and enamels

An oleoresinous varnish consists essentially of a drying oil, a natural or thermosetting synthetic resin, and a solvent thinner. When it is applied to a metal surface, the thinner evaporates and the oil-resin mixture oxidizes and/or polymerizes to form a clear dry film. Such a varnish is known as "long-oil", "medium-oil" or "short-oil", depending on its oil content. A short-oil varnish film is generally faster-drying, less flexible, more impermeable to moisture and more chemical-resistant than a long-oil film.

A synthetic varnish consists essentially of a thermosetting resin and a solvent thinner. When it is applied to a metal surface, the thinner evaporates and the resin polymerizes to form a clear dry film. A synthetic varnish film is generally faster-drying, harder, less flexible, more impermeable to moisture and more chemical-resistant than an oleoresinous film.

An enamel is essentially a pigmented oleoresinous or synthetic varnish. Properties of an enamel vary widely, depending largely on the nature of the varnish vehicle. It may be air-drying or baking, flat or glossy. It may be white, colored, black or metallic (aluminum- or mica-pigmented) in appearance. It may also dry to special textures such as wrinkled, simulated-hammered, etc. Generally an enamel film is harder, tougher and less flexible than a varnish film.

Phenolic varnishes and enamels are inexpensive, hard and durable,



Epoxy baking enamel *is sprayed on caps for ball point pens.* *(Shell Chemical Co.)*

and they have excellent resistance to water, acids and alkalies. They are not usually satisfactory for white, light or pastel colors. Long-oil coatings are used to protect ship hulls, bridges and other outdoor steel structures exposed to weathering, water or corrosive fumes. Short-oil varnishes are used as primers, and short-oil enamels, both air-drying (about 4 hr) and baking (about 1 hr at 250 F), are used on inexpensive metal products, as tank linings, and on food and chemical processing equipment. Temperature limit for continuous service is about 350 F. Phenolic enamels are modified with other synthetic resins where greater flexibility is needed. Phenolic-polyvinyl butyral is used for gasoline containers, phenolic-epoxy for washing machines, and phenolic-alkyd for office furniture. Coatings based on gum-modified phenolics instead of "100% phenolics" are sometimes used to reduce cost where color and durability are not too important.

Alkyd coatings are probably more widely used for metal products than any other type of finish. There are many different types. Straight oil-modified alkyds have good heat- and solvent-resistance and better light stability and outdoor durability than phenolics. However, they are not nearly as resistant to water and alkalies as phenolics, and white enamels tend to yellow. Although widely used as primers, alkyd top coats are often modified with other resins to provide special properties.

Alkyd-amine baking enamels, particularly alkyd-melamines, cure more rapidly (20-30 min at 200-300 F) and provide greater hardness, better alkali resistance and better retention of color than alkyds alone. Alkyd-ureas are often preferred because of better adhesion and lower cost. High-amine white enamels are widely used for indoor appliances such as refrigerators, ranges and washing machines, and low-amine colored enamels are used for auto bodies.

Alkyd-phenolic coatings, though less flexible and light-stable than alkyds, have improved water and alkali resistance; they are used on washing machines and as tank linings.

Alkyd-silicone coatings have better heat resistance, gloss retention, color retention, resistance to yellowing and water repellency than alkyds alone. They are quite expensive. Air-drying low-silicone enamels are available, but high-silicone enamels must be baked at high temperatures (about 1 hr at 400 F). Typical applications for glossy enamels are heaters, hospital equipment and wire insulation. Aluminum-pigmented high silicone coatings withstand continuous temperatures in the 500-700 F range and continue to protect the base metal during brief exposures at temperatures as high as 1500 F. Optimum curing temperature is about 750 F and they are often cured in service. They are used on stacks, exhaust lines and sterilizing racks.

Alkyd-vinyl enamels are much more flexible than alkyds alone and are used to precoat metals to be formed into caps, closures and novelties.

Alkyd-styrene enamels are exceptionally fast-drying. Air-drying and baking types are used to provide a good, one-coat, low-cost finish.

Epoxy coatings are relatively expensive, but have excellent adhesion to metals and excellent alkali-resistance. Unlike the alkali-resistant phenolics and furanes, they are available in light colors. Long-oil varnishes are tough, flexible and weather-resistant. High-build (about 7 mils) formulations are available. Short-oil varnishes are used as primers and drum linings. Epoxy-urea and epoxy-melamine baking (about 6 min at 350 F) varnishes and enamels provide extremely hard, tough, water- and alkali-resistant coatings for drums, tanks, furniture and washing machines.

Silicone coatings are extremely expensive but have exceptionally good heat resistance, resistance to yellowing, chemical resistance, electrical resistance and water repellency. They must be cured at high temperatures (about 1-3 hr at 480 F). Silicone varnishes are used on electric motors and as non-stick films on baking pans. Silcone enamels are used on stacks, heaters, turbines, stoves and boilers. Temperature limit for continuous service is about 500 F.

Furane coatings are more expensive than phenolics but have somewhat better chemical resistance. They are used primarily on chemical process equipment. Temperature limit for continuous service is about 350 F.

Neoprene coatings cure by vulcanization (24-48 hr) to provide an elastomeric film that has excellent resistance to water and chemicals, as well as erosion. Temperature limit for continuous service is about 200-250 F. Special high-build (15-20 mils) types are available. Neoprene is considered a good all-around maintenance coating for chemical process equipment, and for use on ship propeller shafts and centrifugal blowers.

Coumarone-indene coatings are inexpensive and have good resistance to weathering, acids and alkalies. They are used as maintenance coatings in industrial atmospheres.

Natural resin varnishes are based on rosin, shellac, dammar, congo, kauri, manila or similar resins. They are not widely used on metal products today because of the superiority of modern synthetic finishes.

Lacquers

A lacquer is essentially a solvent solution of resins and plasticizers, with or without pigments dispersed throughout. When a lacquer is applied to a metal surface, the solvent evaporates and the resins and plasticizers precipitate out to form a clear or pigmented dry film.

Unlike a varnish or enamel film, the usual lacquer film is based on a thermoplastic resin that does not polymerize further during drying. The resulting films are not as hard, tough or heat-resistant (temperature limit for continuous service is about 150 F) as many varnish or enamel coatings, and they have less solvent resistance than most synthetic enamel coatings. However, some lacquers have outstanding chemical resistance.

Since a lacquer dries primarily by evaporation of solvent, many lacquers can be air-dried. Where high production rates are required, however, many lacquers are force-dried by baking at elevated temperatures. Some lacquers, notably the vinyls, must be force-dried to secure maximum adhesion and gloss.

Nitrocellulose lacquers incorporating other synthetic resins are the lacquers most commonly used on metal products. Among the other resins used are ester gums for better weather resistance; oil-modified alkyds for better adhesion and weather resistance; phenolics for better adhesion, moisture resistance and chemical resistance; and vinyls for better chemical resistance. Clear lacquers are used to protect decorative metal finishes against indoor atmospheres. Pigmented lacquers form hard, tough, attractive coatings for both indoor and outdoor exposures. These lacquers can be force-dried in about 20 min at 180 F. Typical applications are auto bodies, fans, vacuum cleaners, toys and signs.

Vinyl lacquers are tough, flexible, highly impermeable to water and highly chemical-resistant. Because of their lack of toxicity, odor and taste, they are used as linings for beer cans, food containers and food processing equipment. They are also used on other chemical process equipment. Because of their good alkali resistance, glossy, white-pigmented vinyls are used on washing machines. For optimum adhesion and gloss, vinyls are force-dried about 30-60 min at 350-375 F. Most vinyl lacquers are based on vinyl chloride-acetate copolymers, although copolymers of vinylidene chloride with vinyl chloride or acrylonitrile are also used. A versatile "wash primer" is based on polyvinyl butyral and also contains phosphoric acid (which provides an etched surface for good adhesion) and zinc chromate pigment. This primer is compatible with vinyl, nitrocellulose and alkyd top coats and is widely used on ship hulls, auto bodies, railway cars, oil refining equipment and aircraft.

Acrylic lacquers, though more expensive and not as chemical-resistant as vinyls, have good light stability and electrical resistance. Clear lacquers are used on electrical equipment and to protect decorative metal finishes against outdoor atmospheres. Because of their resistance to yellowing, glossy white-pigmented acrylics are used on refrigerators. Acrylics are also used on chemical process equipment. Although air-drying finishes are available, acrylics must be force-dried (about 30 min at 250 F) for maximum adhesion, hardness and gloss.

Rubber derivative coatings such as chlorinated rubber and cyclo-rubber condensates, have good

Vinyl plastisol *dip coating for separator screens used in plating tanks is checked for discontinuities.* *(United Chromium, Inc.)*

resistance to chemicals — especially alkalis—and are often used on chemical process equipment and as tank car linings. Because of their good resistance to salt spray and water, they are also used on boat hulls and decks and on marine equipment.

Bituminous lacquers, based on asphalt or coal tar pitch are used as primers for hot melt bituminous coatings.

Dispersions and emulsions

A dispersion consists essentially of a synthetic resin, fillers, and pigments finely-ground and dispersed in water or in an organic vehicle. A water dispersion is known as a "latex." When a dispersion is applied to a metal surface, the organic thinner or water evaporates, leaving a close-packed mass of solid particles. In some cases these particles coagulate upon air-drying; in other cases they must be fused by heat to form a continuous film. Dispersions make it possible to apply films based on highly-soluble resins, as well as exceptionally fast-drying films based on partially-cured thermosetting resins.

Phenolic dispersions are based on partially-cured ("B-stage") phenolic resins. They are used as rapid-drying primers (about 5 min for handling, 1 hr for lacquering).

Vinyl dispersions, based on polyvinyl chloride, are usually known as "plastisols" or "organosols." In a plastisol the vehicle is primarily plasticizer, and little or no solvent is present. In an organosol the vehicle contains thinners which are nonsolvent for the resin. Formulations can be varied to produce coatings ranging from thin to thick, and from hard and rigid to soft and flexible. Wrinkle finishes are available. Vinyl dispersions must be fused at relatively high temperatures (about 350 F) to provide homogeneous films. Plastisols that produce thick single coats are widely used; films up to 15 mils can be sprayed, and coatings up to ¼ in. thick can be applied by dipping a hot, thick metal part. They are usually applied over varnish primers for good adhesion. Typical applications are automotive dashboards, electroplating racks, tools and dish racks.

Fluorocarbon dispersions are extremely expensive, but provide some of the most chemical- and wear-resistant organic films available. They also have good heat resistance (temperature limit for continuous service is about 450 F) and electrical resistance. Although color-pigmented dispersions are available, unpigmented coatings have optimum properties and are always used for top coats. These coatings must be fused at very high temperatures (500-700 F) and quenched from the fusion temperature. Polytetrafluoroethylene (Teflon) films are more permeable but have better anti-stick properties than polychlorotrifluoroethylene (Kel-F, etc.) films. Typical applications are bearings, baking pans, bobbin guides, tank linings and snow plow blades.

Latices are becoming increasingly important. A number of high-gloss alkyd baking formulations are now available. Styrene-butadiene latices are widely used for maintenance, and vinyl and fluorocarbon types are also available. Chief advantages are in application; namely, elimination of drying odors, particularly important in confined spaces, and reduction of the fire hazard caused by evaporation of inflammable solvents.

Emulsions of the oil-in-water type consist essentially of a high-solids varnish or lacquer emulsified in water. When an emulsion is applied to a metal surface, the water evaporates and the remaining high-solids film sets by solvent evaporation or by oxidation and/or polymerization, depending on its formulation, to form a continuous dry film. In addition to reduction of odors and fire hazards during drying, emulsions offer a special advantage for porous materials as they are not readily absorbed and therefore tend to form smooth films. Among the types of emulsions available are nitrocellulose, vinyl and bituminous lacquers, and alkyd varnishes and enamels.

Other organic coatings

Other types of organic coatings include hot melt coatings, claddings and impregnation coatings.

Hot melt coatings consist of a thermoplastic material that has solidified on the metal surface from a molten state. The thermoplastic may be applied in solid form, then melted and flowed over the surface; or it may be applied in molten form, either by flowing it on or by flame spraying. Since no solvent is needed, extremely thick single coats can be applied, and coatings based on virtually insoluble resins are possible. Flowed bituminous coatings, based on asphalt or coal tar pitch, provide excellent resistance to water and outdoor exposure; a typical use is underground pipe. Flame-sprayed polyethylene coatings are relatively new. A graphite-containing resin is melted and sprayed onto a preheated (400-500 F) metal surface. These coatings are highly inert to chemicals and are used to line storage tanks and drums. Even more recent are wear-resistant nylon coatings supplied by dipping the preheated metal part into a solid form of nylon.

Claddings consist of sheet, film or tape of various plastics and elastomers that are cemented to the metal surface. Sheet and film materials include vinyls, polyethylene, natural rubber, butadiene-styrene rubber and neoprene. They are most commonly used as linings for drums and chemical process equipment. Polyvinyl chloride and polyethylene are available as self-adhesive tape. Plate, sheet and strip of steel, aluminum and magnesium, clad with textured polyvinyl chloride sheet, are commercially available. These clad metals are used for consumer products such as baggage and cabinets, as well as chemical process equipment.

Impregnation coatings consist of organic materials solidified and baked within the pores of porous metal parts, such as castings and powder metal parts. Such coatings are used to provide a better surface for plating, to make the part pressure-tight or to increase the strength and rigidity of the part. Impregnants include thermoplastics such as waxes, greases and bitumens; drying oils such as linseed and tung; thermosetting resins such as polyesters, phenolics and ureas; and polymerizable styrene monomer. (Inorganic materials such as graphite and sodium silicate are also used.) Coatings are applied under pressure, often by vacuum techniques.

Metallic Coatings

Metallic coatings may provide one or more of the following: 1) a decorative finish, 2) a protective barrier against corrosion, 3) a wear-resistant surface, 4) an electrically- or thermally-conductive surface, 5) a highly reflectant surface, 6) a protective barrier against high-temperature oxidation, or 7) a paint base.

As a protective barrier against corrosion, metallic coatings may function in two ways. A corrosion-resistant, nonporous coating shields the base metal from the environment. If the coating is porous or if it gradually becomes porous as a result of environmental attack, however, it can still protect the base metal if its electrochemical potential is greater that that of the base metal; in that case the coating metal corrodes in preference to the base metal, providing sacrificial or "galvanic" protection. Zinc, cadmium, and often other metals, such as aluminum and tin, provide galvanic protection for steel. Effectiveness of most other metallic coatings, unless sealed, depends upon their lack of porosity. Porous coatings of the more noble metals, particularly silver, platinum and gold, actually tend to accelerate the corrosion of steel.

Electroplated coatings

An electroplated coating is applied by making the base metal cathodic in an aqueous solution of a salt of the coating metal, then passing electric current through the solution to precipitate the coating metal by electrolysis. Properties of the coating vary with the composition of the plating solution, current density, agitation, solution pH and solution temperature.

Most of the common electroplates are commercially deposited from more than one type of bath. Plates deposited from different baths may vary considerably. The optimum bath often depends on the base metal; the plate thickness desired; the relative importance of such factors as ductility, porosity, brightness and cost; and the cost of additional operations that may be required, such as buffing or stress relieving. For example, an economic balance determines whether a bright plate should be obtained by buffing the base metal or under-plate, by buffing the plate itself, or by adding brighteners to the plating bath.

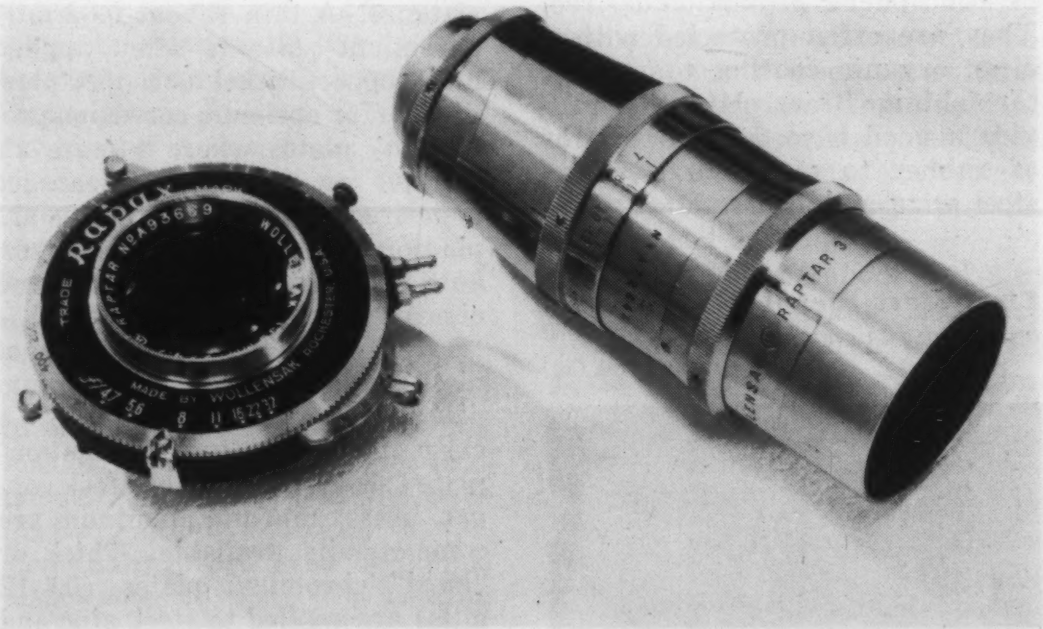
The protective value of electroplates is particularly dependent on their uniformity and porosity. Uniformity varies with the plating bath and the shape of the part. Even with "high throwing power" baths, however, average plate thickness on irregular-shaped parts may be considerably more than plate thickness on recessed areas (unless expensive contour anodes are used). Even a fine, dense plate is somewhat porous, and, regardless of the inherent corrosion resistance of the plating metal, only exceptionally thick electroplates are used in severely corrosive environments.

An electroplate may be applied to the base metal or, in many cases, over another electroplate. A laminar plate makes it possible to take advantage of the greater polishability, the greater corrosion resistance, the greater reflectance, the greater ductility, the more attractive appearance or the lower cost of individual metal plates. There is also some evidence to indicate that a laminar plate is less porous than a single plate of equal thickness.

Zinc plates (about 0.3-2 mils thick) are inexpensive, have good resistance to many atmospheres and provide galvanic protection for steel. Typical applications are switch boxes, conduit, and nuts and bolts. Zinc plates are often protected with a lacquer or varnish in humid atmospheres because of their tendency to form bulky white corrosion products. Lacquered or chromate-treated plates are sometimes used to simulate chromium plate, as on refrigerator racks and fan guards. Zinc plates are also used as a corrosion-resistant paint base. Zinc-plated steel sheet and strip are commercially available.

Cadmium plates (about 0.3-1 mil thick) are more expensive than zinc. However, they provide galvanic protection for steel, they are more solderable and have a lower coefficient of friction than zinc, and they have less tendency to form bulky corrosion products that might interfere with the operation of low-clearance moving parts. Cadmium is also more easily applied to cast and malleable iron, and a thin plate (up to 0.1 mil) is sometimes used as a base for a zinc plate. Cadmium is seldom used as a decorative plate. Typical applications are switchgear, aircraft engines, electronic instruments and hardware.

Tin plates are relatively expensive but they have very good



Chromium plate *provides decorative finish for aluminum lens housing.*
(Aluminum Co. of America)

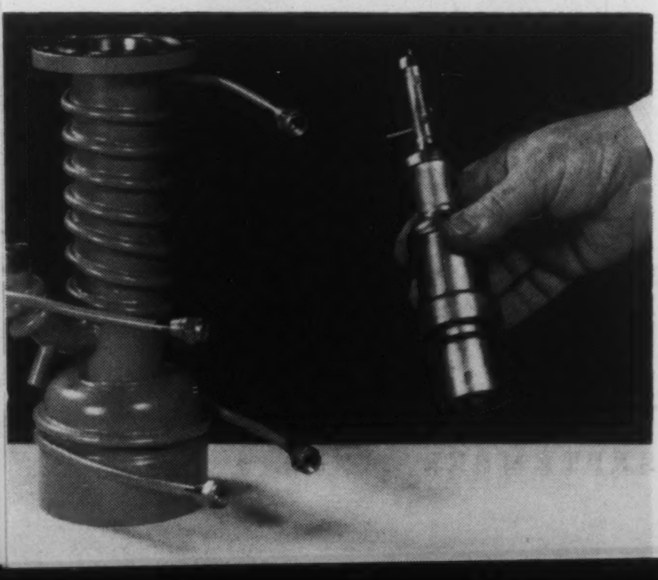
resistance to tarnishing and corrosion, and their corrosion products are not toxic or objectionable to the taste. They are also solderable and more deformable than most electroplates. Plates of about 0.1-3 mils are used on "tin cans" and steel and copper kitchenware; on radio and electronic parts as a base for soldering; on bearings as a base for babbitting; and on other parts where a relatively cheap decorative coating is desired. Thicker plates are used to meet special chemical environments. Porosity of tin plates is sometimes reduced by melting and allowing them to flow out. Tin-plated steel sheet and strip are commercially available.

Copper plates (0.05-2 mils) have good corrosion resistance but tarnish readily. Lacquered bright plates are sometimes used as an inexpensive decorative finish for steel. Since copper plates are corrosion-resistant, not too expensive, and much more easily buffed than steel, nickel plate or chromium plate, they are widely used as a base for nickel, chromium or nickel-plus-chromium electroplates on steel and zinc. Copper plates are also used to provide an electrically-conductive or a more easily brazed surface. Copper-plated steel sheet, strip and wire are commercially available.

Brass plates (usually 0.05-0.3 mil thick) are used on steel, zinc, and sometimes aluminum to simulate brass. They may be applied directly to steel, to a copper flash, or to a copper-bright nickel electroplate, depending on the degree of atmospheric protection desired. They are often protected with a clear organic coating to prevent tarnishing. Brass plates also provide a good base for adhesion of of rubber to steel. Brass-plated steel wire and brass-plated sheet and strip of steel, aluminum and zinc are commercially available. *White brass* plates (about 0.2 mil) applied over a copper plate (about 0.2-0.3 mil) and covered by a chromium flash or a clear organic coating are used as a substitute for nickel-plus-chromium or copper-nickel-chromium plates when nickel is scarce.

Electroless nickel *coating is used on this diffusion pump.*

(Eastman Kodak Co.)



Nickel plates have excellent corrosion resistance. Thick (up to 60 mils or more), ductile plates are used on platens, rolls, kettles, drums and other equipment subject to severe corrosive environments. Thinner plates (0.2-3 mils) are used to protect steel against atmospheric corrosion and to provide a decorative or wear-resistant surface for steel, copper, brass, zinc, aluminum and magnesium. Nickel plates are also used to protect steel and copper electronic parts from high-temperature oxidation. On steel and zinc, they are usually applied over copper plates. On aluminum and magnesium, they are usually applied over a two-layer coating consisting of a zinc immersion coating and a copper flash. Typical applications are machine parts, tools, bicycle wheels and notebook binders. Where greater hardness, tarnish resistance or reflectivity is desired, a nickel plate is covered with a flash of chromium ("chrome plate"). Thin *black nickel* plates are used as a decorative indoor finish for steel. They are protected by a clear organic coating.

Chromium plates have an attractive blue-white appearance, high reflectivity and high tarnish resistance. A thin (about 0.02 mil) chromium plate is often applied over copper, nickel or copper-plus-nickel (for optimum corrosion protection) plates where a more attractive or reflective appearance is desired. Typical applications are plumbing hardware, decanters, auto bumpers, paper shears and cigarette lighters. When nickel is scarce and thinner-than-usual plates are necessary, top chromium plates are often protected by a clear organic coating. Chromium-plated sheet and strip of steel, copper, brass, zinc and aluminum are commercially available. Thick or "hard" chromium plates (0.1-12 mils) are applied to steel, zinc and aluminum where a combination of hardness, corrosion resistance and low coefficient of friction is needed. Typical applications are tools, gages, dies, pump shafts and gun barrels. Porous chromium plates obtained by special techniques are used on piston rings where an oil-retaining surface is desirable.

Lead plates provide good atmospheric protection for steel, particularly in industrial atmospheres. They also provide a good paint base, can be severely deformed without stripping off, and are solderable. Plate thickness ranges from 0.5-8 mils for ordinary applications, such as roofing, cable sheathing, paint cans and nuts and bolts, to as much as 50 mils or more for process equipment subjected to severely corrosive liquids at elevated temperatures. Lead coatings are sometimes burnished or wire-brushed to reduce porosity, and the thicker plates are sometimes applied over a copper flash where better adhesion is desired. Lead-plated sheet and strip of steel and copper are commercially available.

Lead-tin plates are used on bearings (about 10% tin) and as a base for soldering (up to about 60% tin). Plates having about 5-6% tin seem to have optimum corrosion resistance and have been used as a substitute for terne plate (hot dipped).

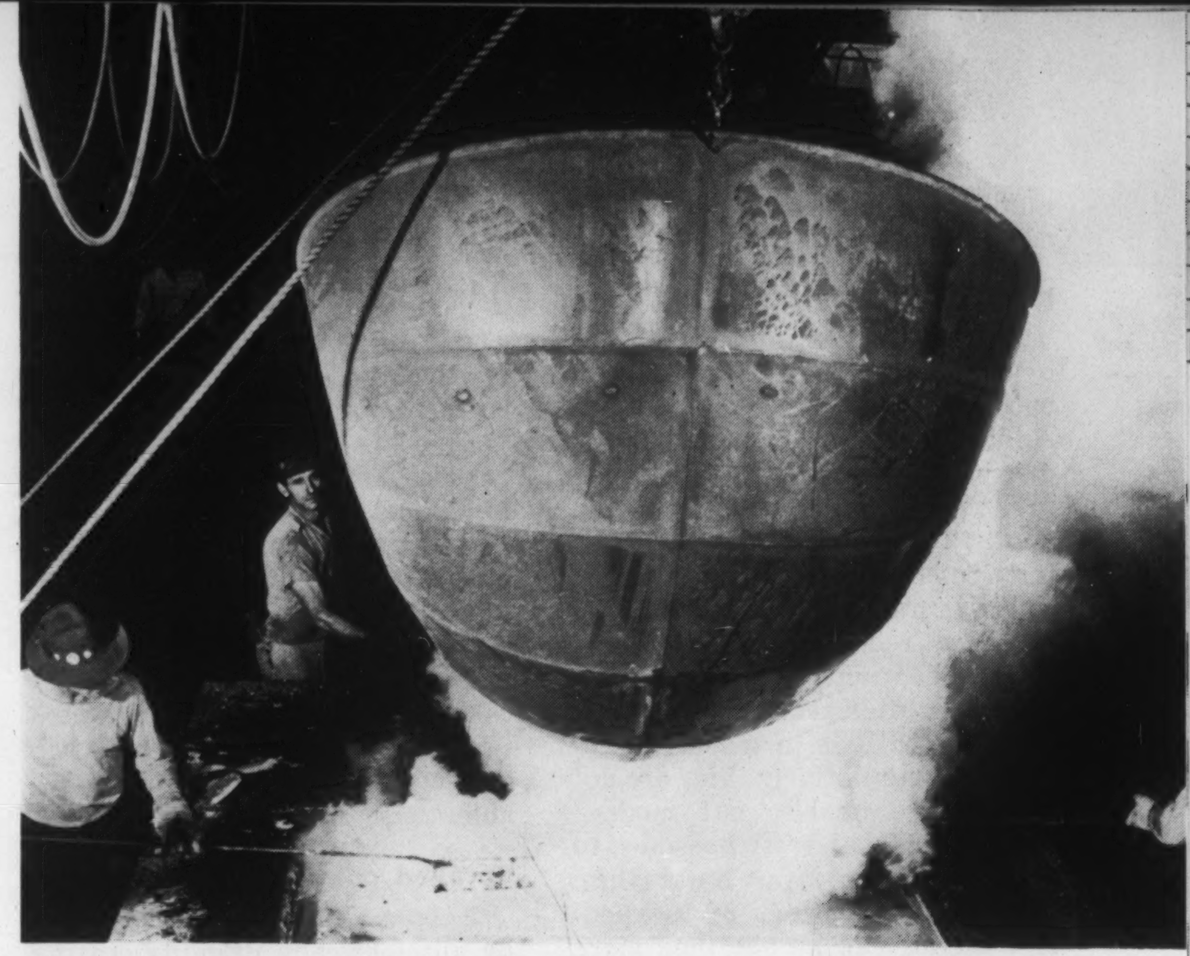
Tip-copper plates containing about 45% tin are known as "speculum." Speculum is white and, buffed to a high luster, resembles polished silver. It is hard and resists tarnish even in contact with sulfur-bearing foods. It is applied to steel (about 1 mil) and copper (about ½ mil) for indoor applications such as tableware, ash trays and plumbing fixtures.

Tin-zinc (about 80% tin) plates are less expensive than cadmium, more solderable than zinc, and less likely than zinc to form bulky white corrosion products in humid environments. Under certain conditions, they seem to offer better outdoor protection to steel than zinc or cadmium plates. Relatively new in this country, tin-zinc is currently being used on steel radio chassis.

Tin-nickel plates (usually 1 mil or more) are bright, tarnish-resistant and solderable and are claimed to be competitive with nickel-plus-chromium for decorative and protective purposes. They have a warmer hue than chromium. An intermediate copper plate is recommended on steel, and an intermediate plate is required on zinc or aluminum to prevent chemical attack by the plating bath. Relatively new, tin-nickel has been used on instrument parts, kitchenware and tableware.

Silver plates have a pleasing decorative appearance, high chemical resistance, good resistance to high-temperature oxidation, high electrical conductivity and good bearing properties. However, they are quite expensive and they tarnish readily in industrial or other sulfur-bearing atmospheres and when in contact with sulfur-bearing food. Plates up to about 2 mils thick are ordinarily used on cutlery, hollow ware, flat ware, musical instruments, surgical instruments and some bearings. Heavier plates (up to about 60 mils) are used on chemical process equipment and heavy bearings. Alloys of silver with cadmium, indium or palladium are sometimes plated to meet special conditions. Silver-plated copper and nickel wire are commercially available.

Gold plates are extremely expensive, but have a pleasing decorative appearance, good tarnish resistance, good resistance to chemicals and high-temperature oxidation, and high electrical conductivity. They are usually applied to copper, brass, bronze, nickel or silver, or over plates of these metals. Flashes (0.001-0.01 mil) are used on band instruments and jewelry and are often protected with a clear organic coating. Plates of about 0.5 mil are used on electrical contact surfaces and waveguides. Thicker plates are sometimes used on chemical process equipment. Gold alloy plates containing copper, nickel, silver or other metals are used where certain characteristic colors are desired. Gold alloy plates are sometimes heat treated to provide special properties.



Hot dip zinc *coating is applied to a ship ventilator.* *(American Zinc Institute)*

Rhodium plates are extremely expensive but have a brilliant blue-white appearance, are highly reflective, tarnish-resistant, hard, wear-resistant, and highly corrosion-resistant even at elevated temperatures. They are applied to nickel, silver or gold or over plates of these metals. Plates up to 1 mil thick are applied over nickel for wear resistance, and plates of 0.02-0.1 mil are applied over silver or gold for electrical contact surfaces. Flashes (0.001-0.008 mil) are used on jewelry and on reflectors for searchlights and movie projectors.

Platinum and *palladium* plates are extremely expensive but have a pleasing decorative white color, are highly resistant to tarnish and chemicals, and have good electrical conductivity. An intermediate plate is necessary on lead, tin and zinc alloys. Platinum is usually applied over a nickel plate and palladium over a silver flash. Plates of 0.04-0.2 mil are used on waveguides. Other applications are electrical contact surfaces, jewelry, and chemical process or laboratory equipment.

Indium plates are soft, silver-white in color, satin-like in texture and more tarnish-resistant than silver. Indium is usually plated over a lead plate, then alloyed by diffusion to form a stronger, more erosion-resistant surface for steel-backed silver bearings.

Immersion coatings

An immersion coating is produced by immersing the base metal in an aqueous solution containing ions of the coating metal. No electric current is required, and coatings are highly uniform. Immersion coatings produced by simple displacement, where the coating metal has a lower solution potential than the base metal, are usually quite thin since deposition continues only as long as the base metal is exposed to the solution. Thicker coatings can sometimes be obtained by a chemical reduction process or by keeping the base metal in contact with a metal less noble than the coating metal. By the latter technique, or by adjusting bath composition to reverse the solution potentials of the two metals, it is also possible to obtain immersion coatings on more noble base metals.

Nickel displacement coatings of about 0.05 mil are used on steel as a base for porcelain enamel and sometimes organic coatings. Hard, dense chemical-reduction ("electroless nickel") plates of about 0.5-3 mils and containing about 5-7% phosphorus are used to protect steel, aluminum and copper against corrosion and wear, especially on parts where a uniform electrodeposited coating would be difficult or impossible to achieve. Typical applications are valves, gears, tube interiors, pistons, threads and bearings.

Tin coatings of about 0.02-0.05 mil provide a bright decorative finish for brass, iron and steel parts such as safety pins, thimbles, paper clips and buttons. Thicker immersion coatings are used to lubricate steel wire in drawing and aluminum pistons during the running-in period.

Other immersion coatings include gold and silver for decoration, tarnish resistance and reflectivity; and zinc, applied to aluminum and magnesium as a base for nickel plating.

Hot dip coatings

A hot dip coating is obtained by immersing the base metal in a bath of the molten coating metal. Adhesion results from the tendency of the coating metal to diffuse into the base metal and form an alloy layer. Most hot dip coatings consist of at least two distinct layers: an alloy layer and a layer of relatively pure coating metal. The alloy layer is usually a brittle intermetallic compound. Hot dip coatings in which the alloy layer is relatively thick are not readily deformable, but modern techniques make it possible to keep the alloy layer quite thin. Fairly thick coatings of inexpensive metals can be obtained more cheaply by hot dipping than by electroplating. Except on simple shapes, however, hot dip coatings are exceedingly non-uniform and wasteful of material. The nature of the process is such that coating metals are restricted to relatively low-melting metals and base metals are limited to high-melting metals such as cast iron, steel and copper.

Zinc ("galvanized") coatings of 0.8-2 mils or more are used on garbage pails, pole-line hardware, auto mufflers, water pipe and air conditioner parts. Coatings with a roughened surface particularly suitable for paint adhesion can be obtained by a special process ("Galvannealing"). Hot dip zinc-coated steel sheet, strip, tubing, pipe and wire are commercially available.

Tin coatings are most commonly used on "tin cans". Hot dip tin-coated steel sheet and strip are commercially available. Tin coatings can also be wiped on by hand.

Lead-tin coatings containing about 3-8% tin ("lead") and about 12-20% or more tin ("terne") are used in thicknesses of 0.2-1 mil or more. Lead coatings are used for roofing, ammunition boxes and ducts. Terne coatings are used for gasoline tanks, paint and oil cans, and door frames. Lead-coated sheet and strip of steel and copper and terne-coated steel sheet and strip ("terneplate") are commercially available. Lead coatings can also be wiped on by hand.

Aluminum coatings (usually about 1 mil) are more expensive but much more atmosphere-resistant than zinc. They are also highly heat-reflective and the aluminum-iron alloy layer is highly refractory. Although these coatings seem promising for more general use in outdoor (especially industrial) atmospheres, they are currently used primarily to protect steel from high-temperature oxidation; typical applications are aircraft fire walls, toasters, auto mufflers and water heater casings. Hot dip aluminum-coated ("aluminized") steel sheet, strip and wire are commercially available.

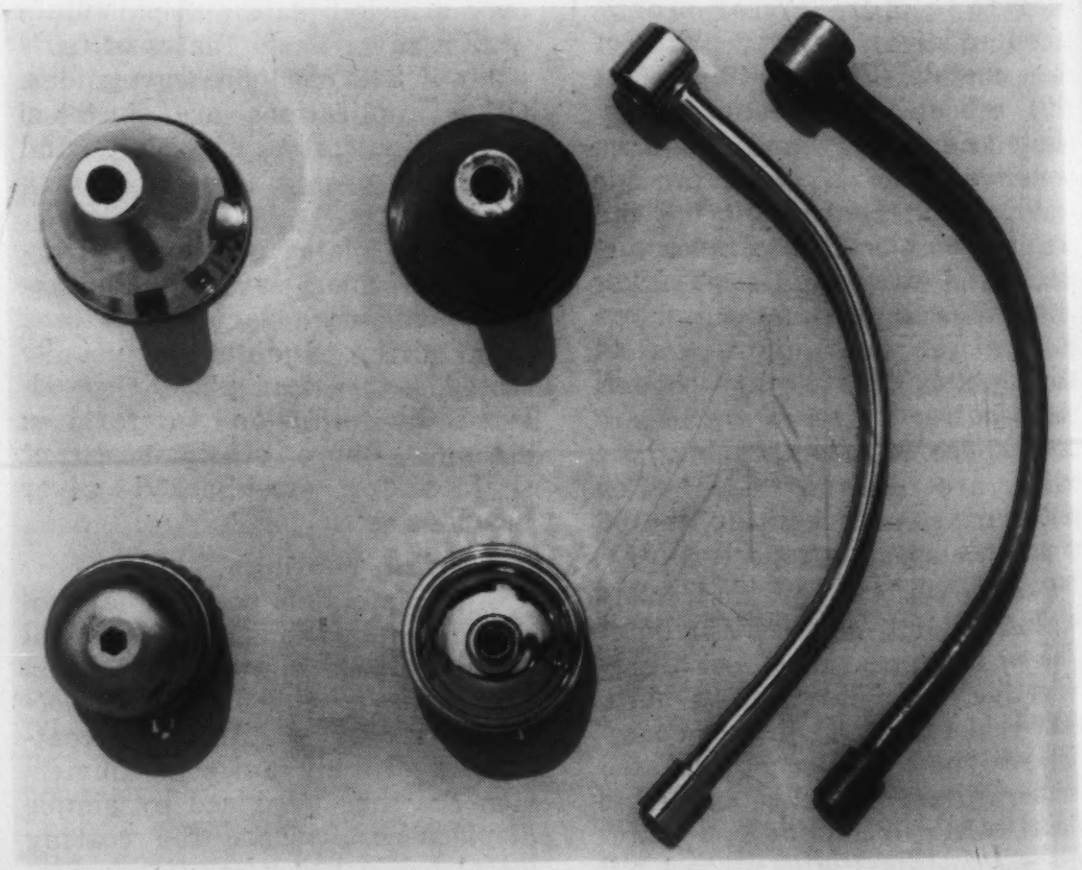
Sprayed coatings

A sprayed coating is obtained by automatically drawing coating metal wire through a nozzle where it is melted in a gas flame and atomized by a blast of compressed air which carries the particles to the base metal. Coatings can also be sprayed in powder or molten form, but these techniques are not widely used for the common metals.

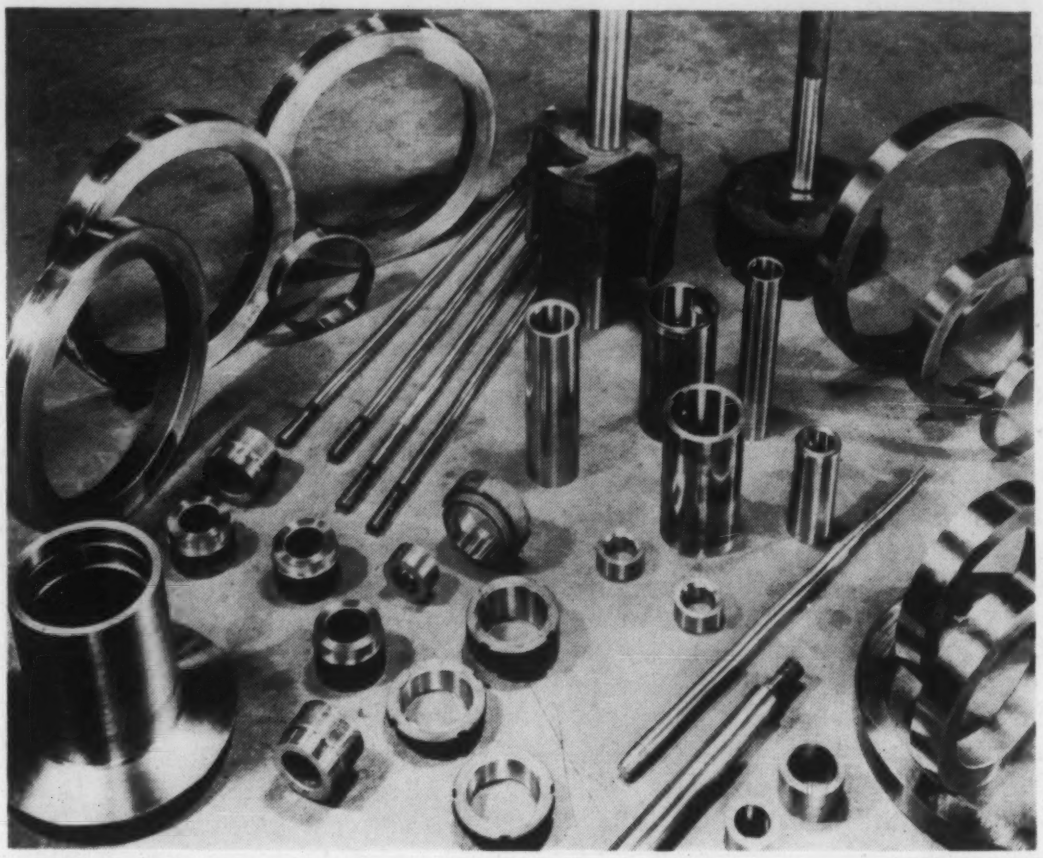
Since most sprayed coatings contain some oxide and the coating particles tend to work-harden upon impact, sprayed coatings are fairly hard and often have excellent wear resistance. Adhesion is not equal to that of plated or hot dip coatings but it is adequate for many critical applications. Sprayed coatings are also quite porous. Their oil retention makes them good bearing surfaces. Effective porosity is sometimes reduced by hammering, wire brushing or heating. However, sprayed coatings are used for corrosion resistance only where they provide galvanic protection, and they are often supplemented by organic coatings.

Zinc and *aluminum* coatings are used primarily to protect steel exposed to water or outdoor atmospheres. Thin zinc coatings (about 1 mil) are applied to fasteners in a revolving barrel. Thicker coatings (3-15 mils) are often sealed with an organic coating—most commonly one to four coats of clear vinyl, aluminum-pigmented vinyl, colored vinyl-alkyd or chlorinated rubber. In general, zinc is used in rural atmospheres and aluminum in industrial or salt atmospheres. Typical applications are large fixed structures such as water towers, boat hulls and tank interiors.

Molybdenum coatings have better adhesion to steel, aluminum and magnesium than other sprayed coatings as the result of their higher application temperature (which causes slight dif-



***Vacuum metallized** finish is applied to steel tubing and stampings (shown before and after) used in a table lamp.* *(F. J. Stokes Machine Co.)*



Hard-facing *cobalt-chromium-tungsten alloy coatings are welded to many parts used in bearing applications.*

(Cleveland Hard Facing Co.)

fusion into the base metal and largely removes oxides by vaporization). Consequently, less thorough surface preparation is needed, and a flash of molybdenum is often used as a base for other sprayed coatings. It also provides an excellent wear surface for journals.

Wear-resistant alloy coatings (up to ⅛ in. thick), such as carbon and stainless steels, monel, aluminum bronze, nickel and others, are used on machine parts. Coating selection depends on severity of the application, corrosive conditions encountered, whether subsequent machining is required, surface finish needed, maximum operating temperature, and nature of the mating metal. Typical applications are valve stems, armature shafts, crankshaft bearings, pistons and pump impellers. Thin (down to 0.5 mil) tungsten carbide coatings that provide flexible wear-resistant surfaces are being custom-applied by a relatively new process. The carbide is applied in the form of a powder and application temperatures are claimed to be low enough so that aluminum can be coated without distortion; other details are not available. Typical applications are machine spindles, cup-drawing dies, plug gages and burnishing broaches.

Other metals applied by spraying include copper for brazing, silver for contact surfaces, and tin- and lead-base babbitts for bearing surfaces.

Vapor-deposited coatings

A vapor-deposited coating usually consists of a metal film condensed from the vapor phase.

Evaporated or "vacuum-metallized" films of aluminum are the most widely used vapor-deposited coatings. They are applied by heating and vaporizing the aluminum in a very high vacuum; the metal vapor then condenses on all "visible" surfaces of the base metal. Since vacuum metallized films are exceptionally thin (about 0.005 mil), they tend to reproduce exactly the surface on which they are applied and they have little inherent abrasion resistance. However, durable mirror-bright films can be obtained by applying them over a smooth lacquer film of one or two layers and protecting them with a top coat of clear lacquer. Other metallic colors are simulated by using a colored top lacquer or by dyeing the top lacquer after application. These films are used primarily on steel and zinc for decorative purposes and are currently limited to indoor exposures. Typical applications are costume jewelry, trim for radio and TV sets, drawer pulls and interior automotive hardware. Tin, cadmium, zinc, selenium and other metals are sometimes applied by vacuum metallizing. Selenium coatings (about 3 mils) are applied to nickel-plated aluminum sheet in the manufacture of selenium rectifiers.

Cathode sputtered coatings are obtained by applying a high voltage across two electrodes (where the cathode consists of the coating metal) in a vacuum. Ion bombardment vaporizes the coating metal which then condenses on the base metal, forming a crystalline, fine-grained coating. Thin films are highly porous, but fairly nonporous coatings of about 0.04 mil can be obtained. Gold and silver films can be applied most rapidly.

Other vapor-deposited coatings can be obtained by a variety of processes in which a volatile compound of the coating metal is reduced or thermally decomposed upon the heated surface of the base metal. These techniques are particularly useful in producing relatively thick coatings of refractory metals and compounds, but they have not yet been used commercially to any important extent except in the production of chromized and siliconized coatings (see "diffusion coatings").

Diffusion coatings

A diffusion coating is a hard, usually brittle, alloy-rich surface layer produced by heating the base metal—ordinarily steel—while in intimate contact with another metal in powder, liquid or gaseous form ("cementation").

"Sherardized" (zinc) coatings on steel are not as protective as plated or hot dip zinc coatings but are satisfactory for mild atmospheres. They are usually applied to small parts such as nuts, bolts and screws, and small machine parts. Such parts are coated in a revolving barrel containing a mixture of zinc and alumina powders at 800 F.

"Chromized" (chromium) coatings of about 4-8 mils on steel have corrosion resistance similar to, and high-temperature oxidation resistance better than, that of high-chromium steel. They are used on valves, pumps, gages, tools and other parts where a combination

of wear and corrosion resistance is desired. Chromized coatings are usually produced by fused salt bath immersion, or by decomposition of chromium diiodide on the base metal (1900-2000 F) and subsequent diffusion.

"Calorized" (aluminum) coatings of about 5-40 mils on steel provide excellent protection against high-temperature oxidation up to about 1600 F. They may be produced by pack or barrel methods, or by spraying followed by heat treatment. Typical applications are stills, retorts, furnace parts, rotary dryers and pyrometers. A somewhat similar coating that protects steel at temperatures up to 1800 F can be produced by spraying on 10-15 mils of a proprietary chromium-nickel alloy, followed by aluminum. At high operating temperatures (1600 F or above) the aluminum diffuses through, alloying with nickel, chromium and iron, to seal the coating.

"Siliconized" (silicon) coatings, obtained by reduction of silicon tetrachloride on the base metal and subsequent diffusion, are used to protect molybdenum against high-temperature oxidation.

Fused coatings

Fused coatings are applied by fusing the coating metal to the base metal. The most common fused coatings are "hard facings" of 1/16-¼ in. applied primarily for wear resistance. They generally consist of hard particles embedded in a somewhat softer matrix. The wear performance of a hard facing is largely related to its overall hardness, its microhardness and its microstructure.

Hard facings are applied in three different ways. One method is to weld them on, using an electrode which may be wire or rod of the coating material, a tube containing the desired alloy elements, or a steel rod with an alloy-containing flux coating. Oxyacetylene, metallic arc and inert gas-shielded arc welding are used. Another method is to spray or otherwise apply the coating material as a powder or paste, then fuse it with an oxyacetylene torch, by induction heating or by heating in a controlled-atmosphere furnace. Still another method, used where exceptionally thick coatings are desired, is to weld or "puddle" into place cast inserts or filler bars of the coating material. These are sometimes covered with another hard facing layer.

Although such materials as cast iron, stainless steels, tool steels and Hadfield manganese steel can be used for hard facings, the majority of hard facings are available as special proprietary materials.

Iron-base alloy coatings contain alloying elements such as chromium, tungsten, manganese, silicon and carbon, and have either martensitic or austenitic structures. Those containing less than 20% alloy, the least expensive group of hard facing materials, are often preferred for large parts and are sometimes used as a base for more expensive hard facings. They have high impact resistance and relatively high hardness. Iron-base alloys containing more than 20% alloy cost more and are less shock-resistant, but are harder and more abrasion-resistant. They are particularly suitable as top coatings over tougher, less expensive undercoats.

Nonferrous alloy coatings are primarily cobalt-chromium-tungsten or nickel-chromium alloys containing elements such as molybdenum, columbium, boron, iron and carbon. These coatings are available in a wide range of strength and toughness. Over-all hardness is about the same as that of the lower-alloy iron-base materials, but these coatings retain most of their hardness at elevated temperatures. They are also highly corrosion-resistant, and some of them are used to protect chemical process equipment. In general, nonferrous coatings can be specified thinner than others (down to 1/32 in.). Because they are smoother, they have less tendency to gall than other hard facings. Wear-resistant bronze coatings such as manganese bronze, phosphor bronze and aluminum bronze are sometimes applied by fusion ("bronze surfacing").

Tungsten carbide coatings generally consist of almost-diamond-hard tungsten carbide particles in a matrix which may be either the base metal or an alloy deposited with the carbide. These coatings offer maximum wear resistance but relatively low impact resistance. Thinner, more flexible tungsten carbide coatings can be applied by another process (see "sprayed coatings").

Other less widely used "diamond substitute" coatings include chromium boride and the carbides of tantalum, titanium and boron.

Claddings

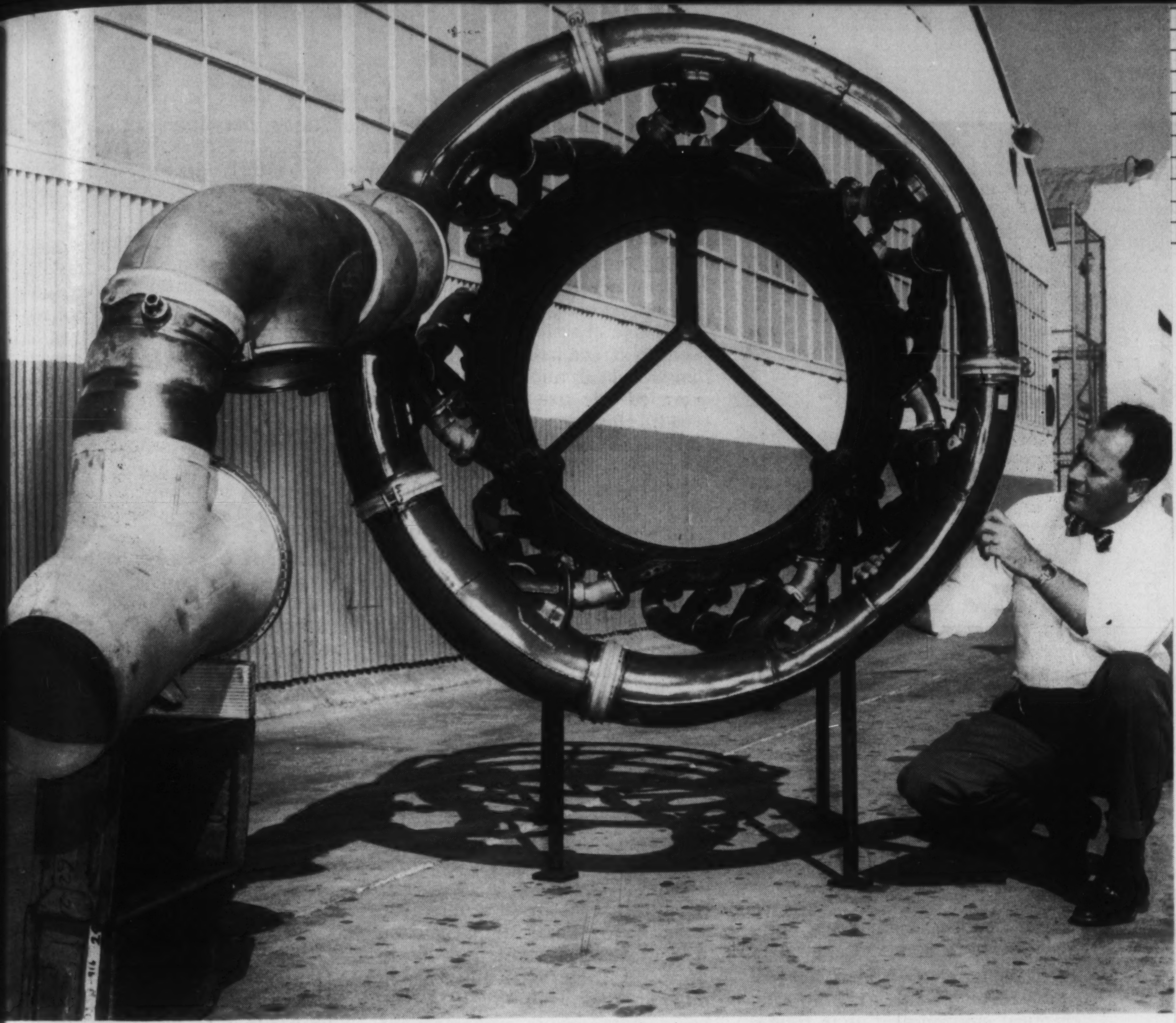
Sheet or plates of corrosion-resistant metals are sometimes welded or brazed to base metals where severe corrosive conditions make necessary a thicker or less porous protective coating than can be economically applied by any other process. A great variety of clad metal plate, sheet, strip, tubing and wire are commercially available (see "Clad and Precoated Metals", M&M, Dec. 1954, pp. 113-128).

Inorganic Coatings

Inorganic coatings consist largely of relatively inert, refractory compounds. In general they are harder, more rigid and more heat-resistant than other coatings. They may provide one or more of the following: 1) a long-lasting decorative finish, 2) a protective barrier against corrosion, 3) a wear-resistant surface, 4) a protective barrier against high-temperature oxidation, or 5) a thermally insulating surface.

Inorganic coatings cover a broad range of silicates, metal oxides and combinations of silicates and metal oxides. In general, predominantly silicate ("vitreous") coatings have optimum smoothness and luster, and predominantly metal oxide coatings have optimum heat resistance.

Vitreous coatings are available in the form of a "frit"—glass-like granules made by fusing acidic refractories, such as quartz and feldspar, with basic fluxes, such as borax, soda ash, cryolite and fluorspar, followed by quenching in water. This frit is ground, either wet (in water) or dry, with opacifiers, coloring agents, and other additions. A wet frit ("wet process") is applied to the base metal as a



Ceramic coating *is used on jet exhaust systems. (Ryan Aeronautical Co.; California Metal Enameling Co.)*

slurry by dipping, flowing or spraying, then dried and fused in a furnace. A dry frit ("dry process") is sieved onto a still-hot, fused wet process coating, then fused. Dry process coatings are used only on castings. Pre-colored frits that offer greater color stability are commercially available and are being used on home appliances.

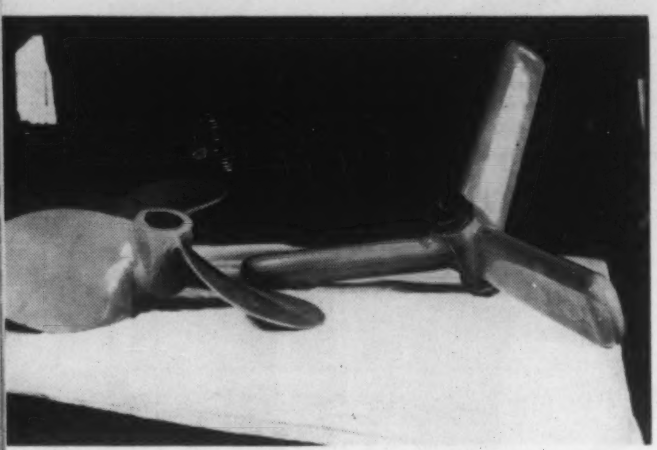
Porcelain enamels

Porcelain enamel coatings consist essentially of oxide color pigments, opacifiers and gases colloidally dispersed in fused silicates. They are smooth, hard and lustrous, and resist temperatures as high as 1000 F (except on aluminum). They may be formulated to provide an attractive, easily-cleaned, durable finish; a chemical-resistant barrier; or a wear-resistant surface.

These coatings generally comprise one, two or three layers. The first layer is usually a 3- to 4-mil "ground coat" (analogous to an organic "primer") containing an oxide of cobalt, nickel or molybdenum that promotes good adhesion with the base metal. Where appearance is not important, a ground coat may be used alone, but ordinarily it is followed by one or two 3- to 4-mil top coats, depending on the thickness required to achieve the desired opacity or protection. The necessity for a ground coat can sometimes be eliminated by using a special titanium-stabilized steel; the resulting thinner coatings are more flexible and thus generally more durable than thicker coatings.

Porcelain enamels are usually applied to special "enameling iron", to certain low-carbon steels when better drawability is needed, and to cast iron having a limited combined-carbon content. They are also applied to a titanium-stabilized low-carbon steel which, in addition to requiring no ground coat for good adhesion, has greater resistance to sagging at firing temperatures. A preliminary nickel electroplate or immersion coating is usually applied to all ferrous metals to improve adhesion. Porcelain enamels are also applied to copper and aluminum.

Two general types of porcelain enamel are most widely used. Titanium types—so-called because titanium dioxide is the opacifier—are preferred for white coatings because of their high covering power which makes necessary only a single 3- to 4-mil top coat. These relatively thin coatings (about 7 mils with a ground coat) have good



***Porcelain enameled** agitator blades improve product purity and reduce cleaning time in chemical processing.*
(Porcelain Enamel Institute)

acid resistance, good abrasion resistance, and good resistance to chipping during shearing, bending, punching and other fabricating operations. White titanium coatings are widely used on stoves, refrigerators, signs, lamp reflectors and sinks.

Pastel-colored titanium coatings can also be obtained but, where deep, bright colors are desired, acid-resistant antimony-type coatings are used. These coatings do not have the covering power of titanium types and require two 3- to 4-mil top coats for good appearance. They are also less abrasion-resistant than titanium types.

Porcelain enamels can be formulated to resist virtually any chemical environment up to 1000 F except strong alkalies and hydrofluoric acid. Frits for acid-resistant coatings generally contain more quartz and feldspar and less fluorspar, cryolite and borax than other frits. These coatings are usually thicker than ordinary coatings (25 mils or more on "glass-lined" equipment) and are fired at somewhat higher temperatures. They are applied to cast iron and steel equipment such as tanks, kettles, vats, piping and tank cars.

Wear-resistant coatings are often used on materials handling equipment. Typical applications are elevator buckets, idler rollers and chutes for coal, concrete and grain.

Coatings for steel may be fired at various temperatures ranging from as low as 1350 to as high as 1600 F. Low-firing frits are used on sheet wherever possible in order to minimize distortion of the part. Sometimes both the ground coat and a top coat can be fired simultaneously. Coatings for cast iron are usually fairly similar to those for steel but some softer formulations can be fired at temperatures as low as 1200 F.

Coatings for aluminum are fired at temperatures below 1000 F and are not as resistant to weathering, wear and chemical attack as other porcelain enamels. Most of them contain lead and are not recommended for use in contact with food. However, they are finding increased use in such applications as store fronts, washing machines, advertising display signs and outdoor furniture. Until recently, coatings for aluminum were being applied successfully only to wrought products, but at least one foundry is now enameling a cast alloy on a commercial basis.

Ceramic coatings

Ceramic coatings are vitreous and metal oxide coatings that are more refractory than porcelain enamels. Ceramic coatings increase the useful temperature range of metals in three ways: by protecting them from erosion, oxidation and intergranular corrosion; by insulating them, thereby keeping actual metal temperature appreciably lower than environmental temperature; and by increasing their over-all strength and rigidity, thereby offsetting some of the loss in properties suffered by metals at elevated temperatures. Thin ceramic coatings can be applied directly to the base metal. Typical applications are jet engine parts, furnace jigs and fixtures, and automobile mufflers.

Low-carbon steels and low-alloy steels of limited carbon content can be protected at temperatures up to 1250 F by 2- or 3-mil coatings of A-19 or A-19H. These coatings (developed by the National Bureau of Standards) are similar to conventional porcelain enamels but have a higher alumina content and are fired at 1600 F. They also have been applied to Inconel and to austenitic stainless steels.

Stainless steels, Inconels, Hastelloys and other high-temperature alloys can be protected at temperatures up to about 1650 F by 1- to 2-mil coatings of NBS A-417 or A-418. These coatings contain chromic oxide (A-417 also contains beryllium oxide) and are fired at 1850 F. Proprietary thin (1/2 mil), flexible coatings suitable for use up to 1800 F are also available.

A number of ceramic coatings aimed at extending the useful service life and temperature range of molybdenum are currently under development. Among them are some coatings that have protected molybdenum during temperatures as high as 1800 F for an extended period and 2800 F for a short exposure.

Still more highly refractory coatings can now be applied by flame spraying. The coating material is fed to the flame in the form of a powder or a sintered rod. Since the coating particles are only semi-molten when they hit the metal surface, the temperature of the base metal remains well below 1000 F. A cermet consisting of a sintered combination of magnesium oxide and nickel has been successfully applied in thicknesses of 1 to 20 mils. Techniques for applying pure metal oxides—particularly oxides of aluminum and zirconium—have also been developed (see article in this issue, p. 96, for further details). These coatings can withstand temperatures of 3000 F.

Somewhat porous refractory coatings (usually about 1 mil thick) can be applied by "solution spraying". A water solution of a metallic salt is sprayed onto the warm base metal, the heat evaporating the water and decomposing the salt to the oxide. Zirconium oxide coatings can be produced by decomposing ammonium zirconyl carbonate at about 425 F, and chromium oxide coatings by decomposing chromium nitrate at about 700 F. Oxides of titanium, cerium and magnesium have also been deposited by this method. Applications for these new coatings are currently being explored.

For more information—

Space limitations prohibit an adequate bibliography. However, if you want to know more about any of the coatings or processes mentioned in this article, please feel free to contact us. We will be glad to give you additional information or to refer you to sources of more detailed information.

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MATERIALS ENGINEERING FILE FACTS

MATERIALS & METHODS • SEPTEMBER 1955 • NUMBER 304

MATERIALS DATA SHEET

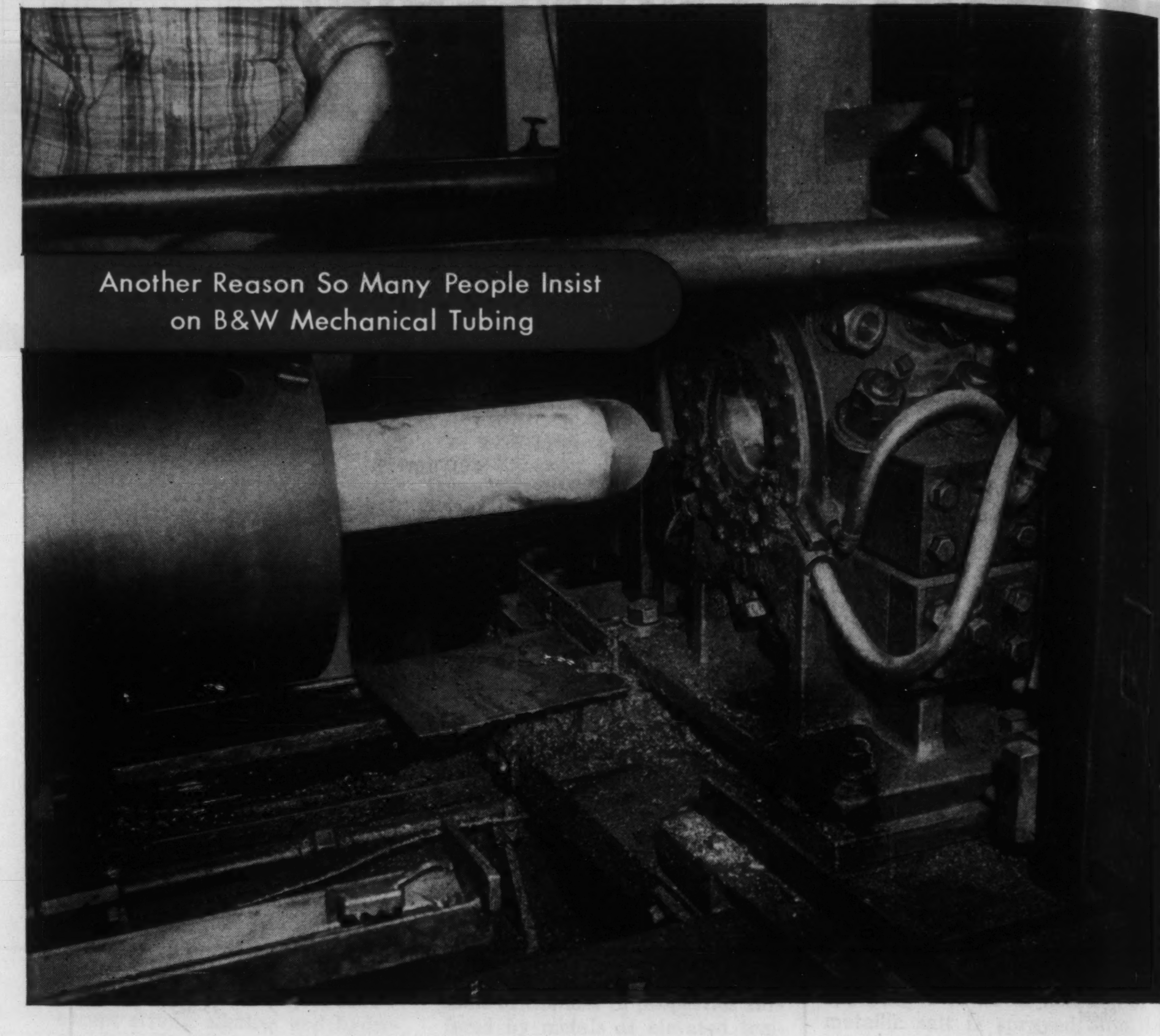
Vulcanized Fibre

Type	Bone Grade	Commercial Grade	Electrical Insulation Grade
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.047–0.054	0.037–0.049	0.031–0.04
Thermal Cond, Btu/hr/sq ft/ft/°F	0.17	0.17	0.17
Coef of Exp per °F	1.4 x 10^{-5}	1.4 x 10^{-5}	1.4 x 10^{-5}
Spec Ht, Btu/lb/°F	0.40	0.40	0.40
Dielectric Str, min v/mil (1/16 to 1/8 in.)		150	175
MECHANICAL PROPERTIES			
Mod of Elasticity in Tension, psi	0.8–1.2 x 10^{6}	—	—
Tensile Str, (minimum) psi			
Sheets	6000/8000^{a}	5000/8000^{a}	6000/8000^{a}
Rods	8000	7000/7500^{b}	—
Tubes	6500	6500	—
Comprehensive Str (minimum) psi			
Sheets	30,000	20,000	—
Rods	8000	6000	—
Tubes	9000/10,000^{c}	9000/10,000^{e}	—
Mod of Elasticity in Flexure, psi	0.7–1.0 x 10^{6}	—	—
Flexural Str, (minimum) psi			
Sheets	13,000/15,000^{a}	11,000/14,000^{a}	—
Rods	15,000	13,000/14,000^{b}	—
Tubes	—	—	—
Bursting Str (minimum)			
Sheet	—	—	75–325^{a}
Hardness, Rockwell (minimum)			
Sheets	R80	R50	R50
Impact Str, Izod, ft-lb per in. of notch			
Sheet flat	3.0/5.0	3.5/8.0	—
Sheet edge	0.8/2.0	1.0/3.0	—
FABRICATING PROPERTIES Machinability Index	Excellent machining, spinning and forming qualities. Can be threaded, swaged.		
AVAILABLE FORMS	sheets, rods, tubes	sheets, rods, tubes	sheets
USES	clutch disks, gears, cams, thrust washers, bushings, threaded parts, terminal blocks.	washers, bobbins, insulation, shock-absorbing plates.	armature slot liners, end laminating coil insulation, arc shields.

NOTE: Lower value of a mechanical property applies to transverse tests, higher to longitudinal tests.
[a] *based on thickness.*
[b] *based on diameter.*
[c] *based on wall thickness.*

Prepared with the assistance of Continental Diamond Fibre Co.

For more information, Circle No. 523



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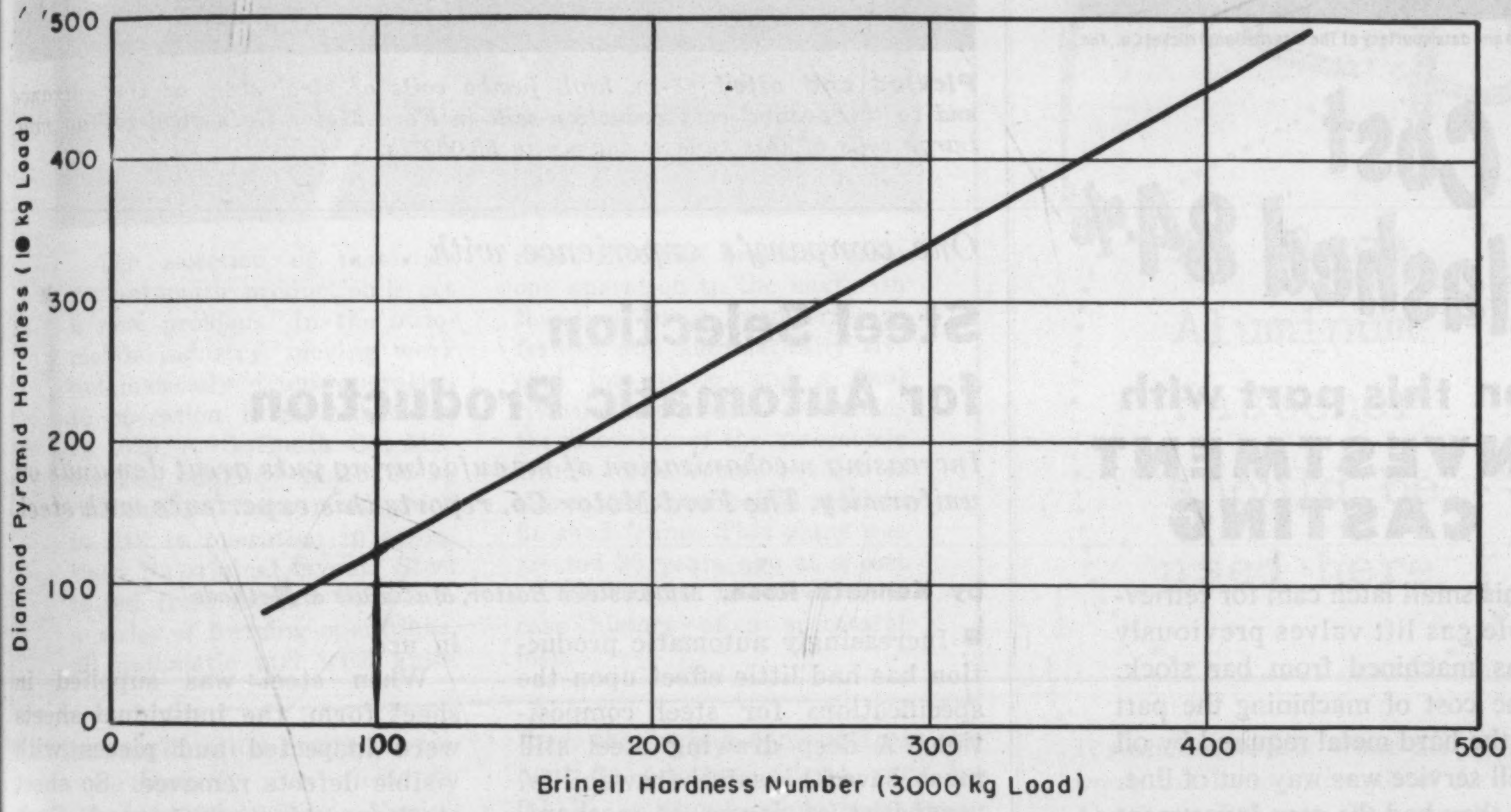
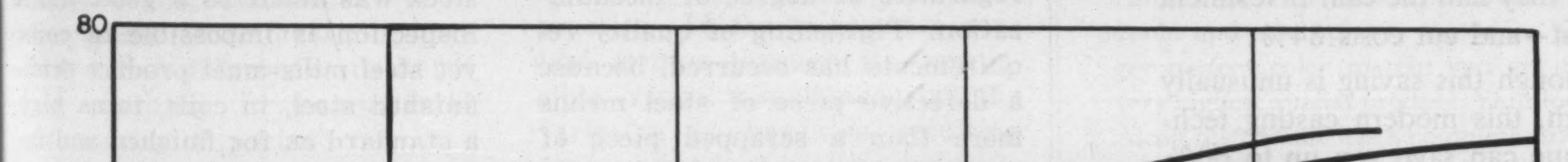
MATERIALS & METHODS • SEPTEMBER 1955 • NUMBER 305

Hardness Correlations for Titanium Alloys

The curves drawn are the best fit obtainable from data for 31 binary iodide titanium-base alloys, in addition to a value for unalloyed iodide titanium. The alloys studied were mostly single phase alpha and beta alloys which were composed of a large number of different solutes, including the interstitials, extending over wide ranges of composition. The hardness values are based on the results of at least three readings on each of three specimens for every alloy. Little scatter was encountered in the data and it is believed that the correlations are accurate within narrow limits.





Prepared by J. J. Rousch and D. J. McPherson
Armour Research Foundation

Photo and data courtesy of The International Nickel Co., Inc.

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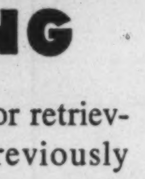

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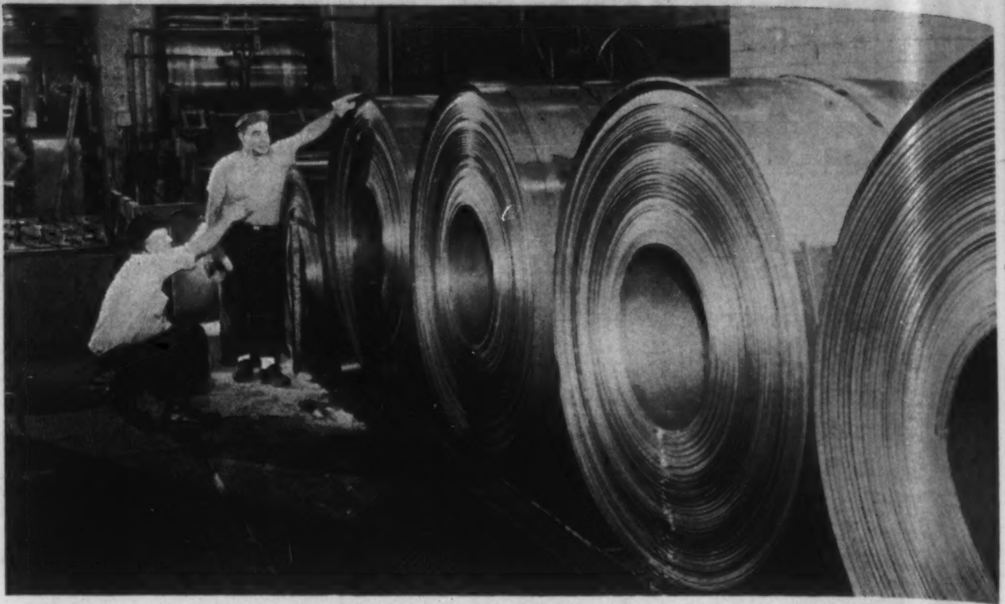


Pickled and oiled *66-in. high jumbo coils of steel strip at the entrance end to three-stand cold reduction mill in Ford Motor Co.'s steel rolling mill. Large coils of this type weigh up to 50,000 lb.*

One company's experience with . . .

Steel Selection for Automatic Production

Increasing mechanization of manufacturing puts great demands on uniformity. The Ford Motor Co. reports this experience with steel.

by Kenneth Rose, *Midwestern Editor, Materials & Methods*

■ Increasingly automatic production has had little effect upon the specifications for steel composition. A deep drawing steel still must have the same drawability, regardless of degree of mechanization. Tightening of quality requirements has occurred, because a defective piece of steel means more than a scrapped piece of work—it can cause a shutdown in a whole production line. Potential loss of production has caused steel users to demand and get better quality, sometimes at increased material cost.

Coiled steel

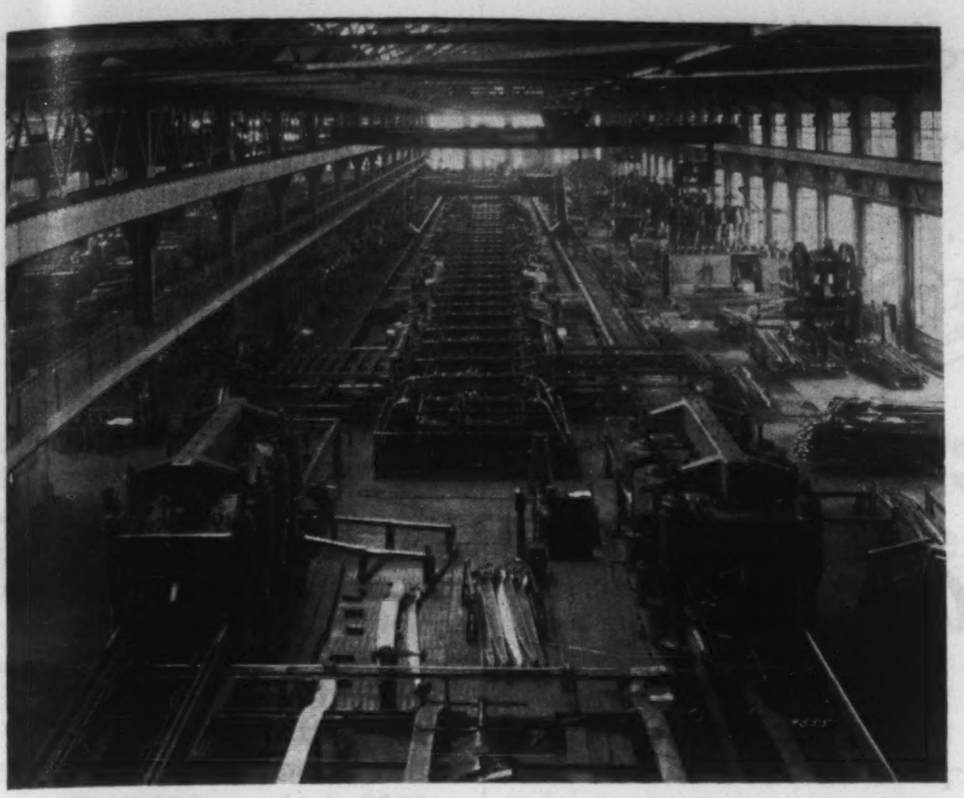
There is an increasing demand for steel in coils, to be fed into automatic presses after a pass through leveling rolls. Larger and larger coils are decidedly in the limelight. From the advent of the strip mill in the 1930's to about 1946, most steel supplied was narrow stock. Today, about 25% of the steel goes into wide coils. The size of the coils has increased greatly, too. A few years ago 20,000-lb coils were about the largest. Today, 50,000-lb coils are in use.

When steel was supplied in sheet form, the individual sheets were inspected and pieces with visible defects removed. So sheet stock was about 98% good. Such inspection is impossible in coils, yet steel mills must produce semi-finished steel, in coils, to as high a standard as for finished and inspected sheets.

Steel suppliers are not the only ones faced by a problem. Use of steel in coils creates shipping difficulties and in-plant handling of large steel coils is much harder. Most users have found it necessary to install heavier cranes or trucks to move coils inside the plant, and heavier stands for feeding the presses. Storage of coiled steel also requires a certain amount of care. If coils are piled too high in storage, the bottom layers are distorted.

Heat treatment

Heat treat superintendents report that difficulties in continuous process operations center about the variations in steel composition. The most common complaint is



The selection of materials for automatic production is not a new problem. In the automobile industry, moving work automatically from operation to operation is an old story. In 1920, A. O. Smith Co., Milwaukee, designed and built an "automated" frame plant which is still in operation in essentially its original layout. Steel is fed from narrow coils into a series of forming operations, all automatic and with automatic material transfer from one operation to the next. On the line, cross members are formed and automatically riveted into place, and a final riveting operation completes the assembly of the automobile frame. The entire process is automatic from coiled steel to finished frame. This plant was erected 35 years ago at a cost of $8,000,000. It serves as a case history of a successful idea.

that the specification limits are too wide, particularly for elements that effect hardenability. Variations occur from heat to heat which cause differences in hardness, resulting in non-uniform performance of parts.

In the plain carbon steels, the permissible range in composition for carbon and manganese, the worst offenders, is as follows:

Low carbon steels
Carbon range—0.07%
Manganese range—0.30%

Medium carbon steels
Carbon range—0.07%
Manganese range—0.30%

High carbon steels
Carbon range—0.12-0.13%
Manganese range—0.30%

Steel producers usually allow themseves two points of carbon above and below the range given in the composition specifications. In a medium carbon steel, there fore, the carbon content from one heat to another might vary by 0.11% without violating trade practice. If the manganese content swings through its permissible range simultaneously, the variation in hardness resulting from a standard heat treatment is severely aggravated.

Mechanized heat treat furnaces can lose efficiency if batches of steel have to be segregated, since manual handling is introduced into a system installed to reduce such handing. If the heats of steel are relatively small, the continuous furnace is no better than a batch furnace, since the treatment must be changed to produce the same physical properties in two different steels. High production of uniform parts is economically impossible under such conditions. Here are two examples:

■ A company producing automobile parts reported variations in hardening a part made of SAE

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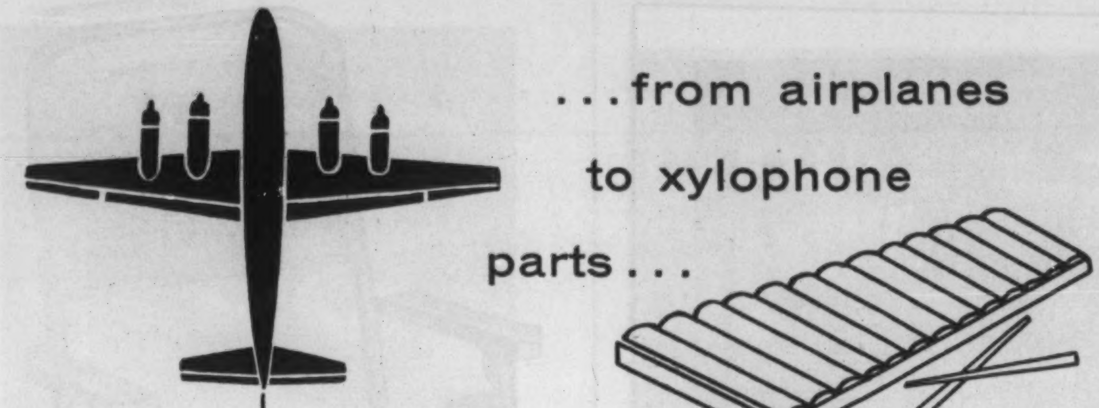

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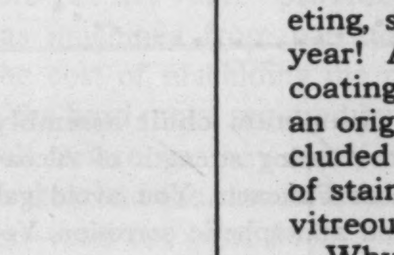

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continued from page 139

1137 steel. Carbon content moved through a 6-point range in several batches. The hardness resulting from a standard treatment in a mechanized furnace swung from 28 Rc to 45 Rc.

■ 1020 steel hooks cyanided and quenched in a high-production heat-treat installation suddenly began to show a core hardness so high that they broke in service tests. The hardness of the pieces at the core was Rc 44. Original steel was analyzed, and the carbon content was found to be 0.26%, while the upper limit specified for carbon content in the SAE 1020 steel was 0.23%. The carbon content was 0.01% above the 0.02% spread usually permitted. Large grain size in the high-carbon batch also contributed to the hardening of this ordinarily non-hardenable steel.

In defending their composition limits, steel manufacturers say that they represent the best results obtainable regularly with standard practice. Even when a customer is willing to pay the premium price for special ranges in composition, it is usual for the steel manufacturer to select a heat that falls within the desired range rather than to attempt to make a heat of steel to narrower composition limits.

In all of this, steel users agree, the decision as to whether to accept drawing steel with more than a minimum of defects, or heat treatable steel with wider composition range than desirable, or whether to pay a premium for special steel and make it up in smoother running automated production lines depends on the current steel market. If steel is in short supply, the user may have to take what is available and work out his difficulties in his mechanized production lines, or else pay the premium for special composition. When steel supply is adequate, large users can frequently get selected heats of standard composition that will perform satisfactorily without payment of premiums.

New Materials, Parts and Finishes | and related equipment

Cermet Coatings for High Temperature Protection

A nickel-magnesium oxide cermet coating that can be applied by flame-spray or brush techniques has been developed for protecting metals during high temperature service. Coatings are said to have high resistance to hot gas erosion and high temperature oxidation, as well as low thermal conductivity and good shock resistance. They can be applied to metals such as mild steel, Inconel, stainless steels, Hastelloys, and Vitalliums. Developed by *Metal Hydrides, Inc.*, 12-24 Congress St., Beverly, Mass., the coatings are composed of 66.6 nickel-33.3% magnesium oxide. They are expected to prove particularly useful for protecting jet and rocket engine components.

Alternate application methods

Flame spraying is the most common method of application and requires a powder gun with oxyacetylene flame. Before application all parts should be sand blasted with silicon sand or silicon carbide. Areas to be coated are first heated with the flame and a 5 to 10 mil build-up is applied. Then the adjacent area is coated before working back over the original area until desired thickness is deposited. Oxidation-resistant materials should be kept near red heat for best result. Mild steel surfaces should be kept cooler. A 20 mil thickness normally gives optimum physical characteristics, though Ni-MgO can be applied in thicknesses up to 30 mils.

Coatings can also be brush-applied by using a mixture of 50% primary materials and 50% presintered material mixed with a 20% solution of "C" brand sodium silicate. Coatings are applied by brush, allowed to dry, then matured by oxyacetylene torch at 2100 to 2200 F. Coatings 0.015 to 0.030 in. thick can be applied in this way. For best results mild steel should be pre-coated with nickel. Inconel provides the best bond, while stainless steels provide poor bonds.

Properties of coatings

Tests at 2800 F of coatings applied by either method showed a maximum temperature differential through the coatings of 700 F. In one test on monel, temperatures of 4600 F were held for 5 min before failures, indicating a temperature differential to 2000 F. The accompanying table lists values indicative of properties of the coatings applied to various metals.

(More New Materials on p. 144)

PROPERTIES OF NI-MgO COATINGS

Method[1] of Appl.	Flame Sprayed Undercoat	Adherence 90 Deg Bend	4 Hr Oxidation Test at 1800 F	Thermal Shock, 10 Cycles from 1800 F	Five Min[2] Endurance at 2800 F	Torch to Failure, Temp and Elapsed Time
1020 MILD STEEL						
A	None	Excellent	Excellent	Excellent	Excellent	3600 F 3 min
B	None	Failed	Good	Excellent	Excellent	3300 F 1.5 min
C	None	Failed	Good	Excellent	Excellent	3700 F 3.25 min
C	Nickel	Very Good	Excellent	Excellent	Excellent	3500 F 2.5 min
310 STAINLESS STEEL						
A	None	Excellent	Excellent	Excellent	Excellent	3600 F 3.0 min
B	None	Good	Poor	Excellent	Failed	4200 F 3.75 min
C	None	Good	Poor	Excellent	Failed	4200 F 4.25 min
INCONEL						
A	None	Excellent	Excellent	Excellent	Excellent	3900 F 3.25 min
B	None	Good	Excellent	Excellent	Excellent	4300 F 4.5 min
C	None	Good	Excellent	Excellent	Excellent	4600 F 4.5 min

[1] *Methods of application*
A—Flame sprayed presintered powder.
B—Presintered powder brushed on and torched.
C—50% presintered—50% raw, brushed on and torched.

[2] *Endurance test:*
Flame sprayed coating on Inconel gave temperature difference of 400 F, while 50% Presintered and 50% Raw brushed on and torched on Inconel gave temperature difference of 650 F.
50% Presintered and 50% Raw brushed on and torched on mild steel with nickel undercoat gave temperature difference of 800 F (coated surface 3500 F, uncoated surface 2700 F).

Acknowledgment; Most data taken from test work by Ohio University Research Foundation, on contracts from Army Air Force, and the Bureau of Ships.

New Materials, Parts and Finishes

and related equipment

New Precipitation Hardenable Stainless Alloys

Four new precipitation hardenable stainless steel casting alloys have been developed recently by *Cooper Alloy Corp.*, Hillside, N. J. Three of the alloys are variations of the 19 chromium, 9% nickel type stainless. By introducing and varying molybdenum, copper and silicon, keeping carbon below 0.08% and manganese below 1%, variations in hardness and ductility have been gained. Corrosion resistance of the three alloys is said to equal or surpass that of type 316 stainless. The fourth alloy is a precipitation-hardenable version of the 20 chromium, 29% nickel, type 20 alloy which has particularly good resistance to hot sulfuric acid and good resistance to many other corrosive solutions. The accompanying table lists some of the alloys' mechanical properties.

The four alloys are:

PH55A—A high strength, high hardness alloy with fair ductility, designed for use in applications where erosion- and abrasion-resistance are critical or for stressed parts in corrosive applications. Limits on composition are 0.08 max carbon, 19.5-20.5 chromium, 8.5-9.5 nickel, 3.75-4.25 molybdenum, 3.0-3.75 silicon and 1% max manganese.

PH55B—A ductile, high strength alloy of medium hardness, designed to provide shock resistance and high strength in corrosive applications. Limits on composition are 0.08 max carbon, 19.5-20.5 chromium, 8.5-9.5 nickel, 3.25-3.75 copper, 4.75-5.25 molybdenum, 1.25-1.75 silicon, and 1% max manganese.

PH55C—An alloy with high hardness, low ductility suited for non-stressed corrosion-resistant parts. Limits on composition are 0.08 max carbon, 19.5-20.5 chromium, 8.5-9.5 nickel, 2.75-3.25 copper, 3.75-4.24 molybdenum, 3.25-3.75 silicon, and 1% max manganese.

PH20—A gall-resistant alloy with superior corrosion resistance. Limits on composition are 0.07 max carbon, 19-22 chromium, 27-30 nickel, 3-4 copper, 2-4 molybdenum, 1.5 max silicon, 2.5 max manganese, 1 max columbium and 0.10-0.15% nitrogen.

PHYSICAL PROPERTIES OF PH STAINLESS STEELS[1]

	PH55A	PH55B	PH55C	PH20
Tens Str, psi	139,000	139,000	185,000[3]	[2]
Yld Str, psi	106,000	105,000	150,000[3]	[2]
Elong, %	8	21	2	[2]
Hardness, BHN	341	293	415	229
in WQ condition	262	226	285	187

[1] *In precipitation-hardened condition unless otherwise designated.*
[2] *Data not yet available.*
[3] *Extensive variations from this value may be expected.*

New Resins for Premix Molding

Three new Plaskon polyester resins designed for use in premix or "gunk" molding have been developed by *Barrett Div., Allied Chemical & Dye Corp.*, 40 Rector St., New York 6. They are said to be suitable for mixing with reinforcing materials such as chopped glass, sisal or asbestos prior to molding. Premix molding involves molding, by conventional compression or transfer techniques, resin systems which contain random chopped fibers of reinforcement. Though parts produced in this manner do not possess the strength of mat or cloth reinforced plastics parts, they offer economies in speed of forming and intricacy of shapes possible (for more details see article on premix molding, p. 104).

Each of the three Plaskon resins has its own characteristics for

TYPICAL PROPERTIES OF PLASKON PREMIX COMPOUNDS

	PE-40	PE-51	PE-55
Hot Barcol Hardness (30 sec after curing)	38	8	13
Cold Barcol Hardness	58	45	53
Ult Flex Str, psi			
Room temp	17,900	15,900	16,900
200 F	8110	5590	7380
After 2-hr boiling	14,500	10,400	14,500
Mod of Elast in Flex, 10^6 psi			
Room temp	1.6	1.56	1.54
200 F	0.69	0.46	0.52
After 2-hr boiling	1.07	1.18	1.17
Ult Tens Str, ps	[1]	3400	6120
Water Absorption, 24 hr, %	0.36	0.19	0.149
Shelf Life of Mix at 73 F, days	7	7	8

[1] *Value not yet determined.*

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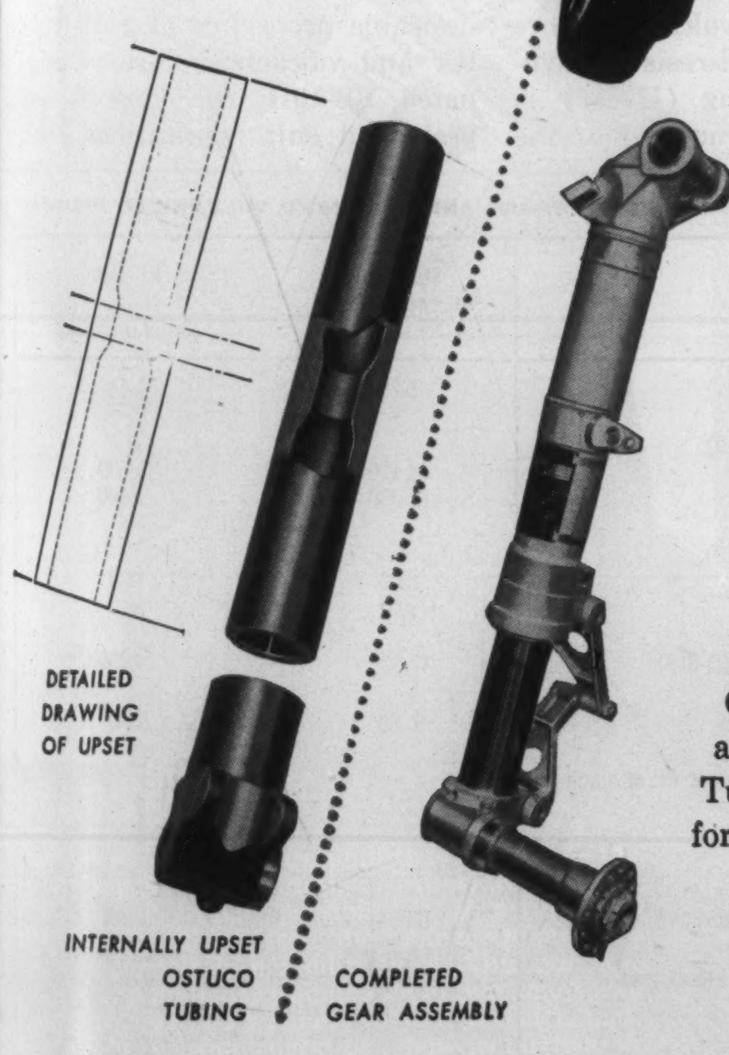

Landing gears, manufactured by The Cleveland Pneumatic Tool Company for North American Aviation's F-86H, have piston tubes machined from internally upset OSTUCO tubing. The upset construction of these *special-quality* OSTUCO tube forgings keeps machining to a minimum and permits faster processing. Savings are 25% . . . or $4.95 per unit.

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LUSTER-ON NS

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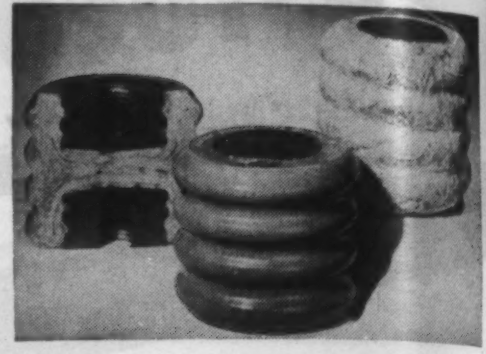
specific molding jobs.

PE-40—A rigid resin containing diallyl phthalate. It permits fast curing cycles and produces molded parts with particularly good surface characteristics. It is said to have high flexural strength, modulus of elasticity and hot strength.

PE-51—A resilient, high-viscosity resin containing diallyl phthalate. It is designed specifically for those jobs which require materials with sufficient flexibility to minimize cracking around core pins and inserts.



PE-55—A resilient resin containing vinyltoluene. It is a medium viscosity resin available at a lower price than PE-40 and PE-51.

Rubber-Sized Fibre Sheet Has Higher Resiliency

A new grade of vulcanized fibre incorporating an oil-resistant synthetic rubber sizing (Hycar) is said to combine a number of the desirable properties of both rubber and vulcanized fibre. Designated RS-10H, the fibre is expected to suit applications such

COMPARATIVE PROPERTIES OF RS-10H AND STANDARD VULCANIZED FIBRE[1]

	Standard Vulcanized Fibre (0.092 in. thick)	RS-10H Fibre (0.109 in. thick)
Density	1.28	1.14
Tensile strength, psi (D-619)		
MD	15,500	11,500
CD	10,000	8500
Water absorption, % (D-619)		
2 hr	18.0	18.0
24 hr	50.0	50.0
Compressive strength, psi (D-619)	42,000	26,000
Hardness, Rockwell (D-619)	R 89	R 47
Impact strength, Izod, ft-lb per in. of notch		
MD	2.7	2.0
CD	2.3	1.8
Compressibility, NVF Method,[2] in./in. of original thickness	0.064	0.109
Recovery, in./in. of original thickness	0.043	0.073
Sliding friction coefficient:		
(a) fibre on fibre (normal calender)	0.11	0.16
(b) fibre on ground steel	0.11	0.14
Stiffness (Gurley RD), milligrams 0.015 in. thick specimen, ½ in. x 3½ in., 50% R.H.		
MD	12,000	10,000
CD	6000	5000

[1] *All specimens conditioned per ASTM D-619, 48-hr at 122 F and tests conducted at 73F and 50% R.H.*

[2] *Test performed on 1-in. square specimen by applying load to ½-in. square area at rate of 0.1 in. per min to 3,000 pounds.*

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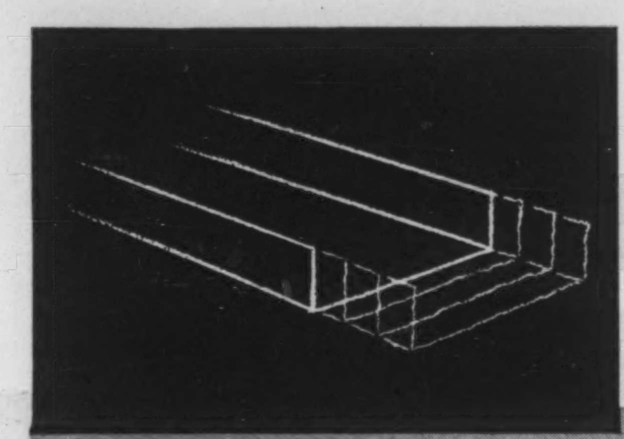

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The work is either manually or automatically placed directly on a hearth which is designed to move forward quickly a few inches, stop suddenly, and then return to its original position. The sudden jolt slides the parts through the furnace. An alternate arrangement is set up so that the hearth moves forward slowly, halts, then snaps back to its original position. Either method assures uniform heat treatment of each individual part.

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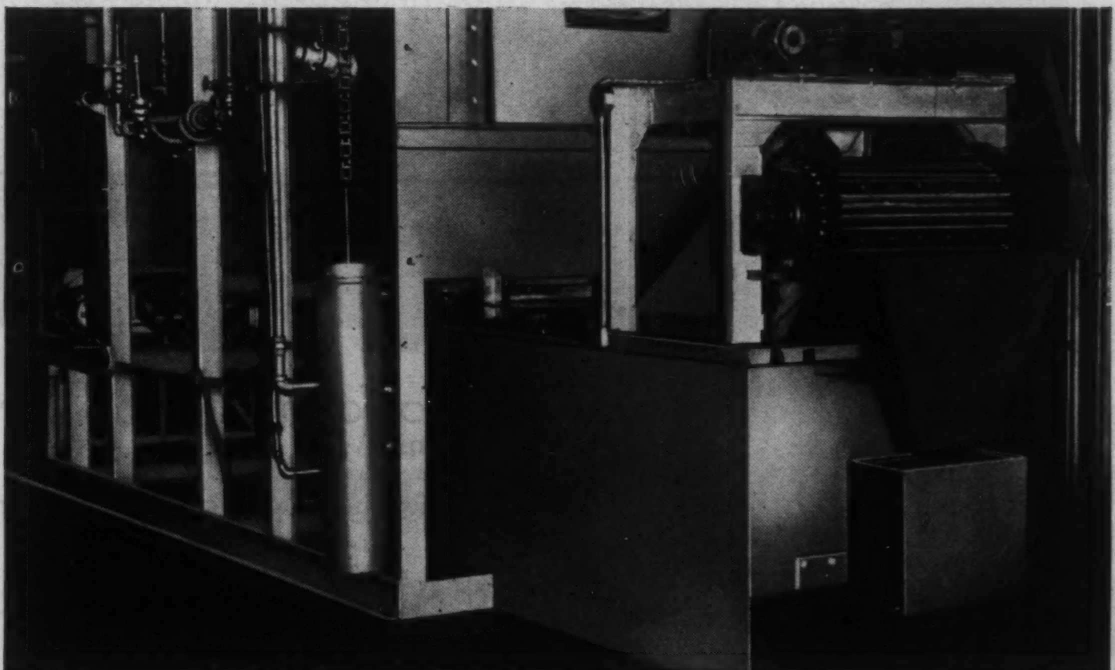

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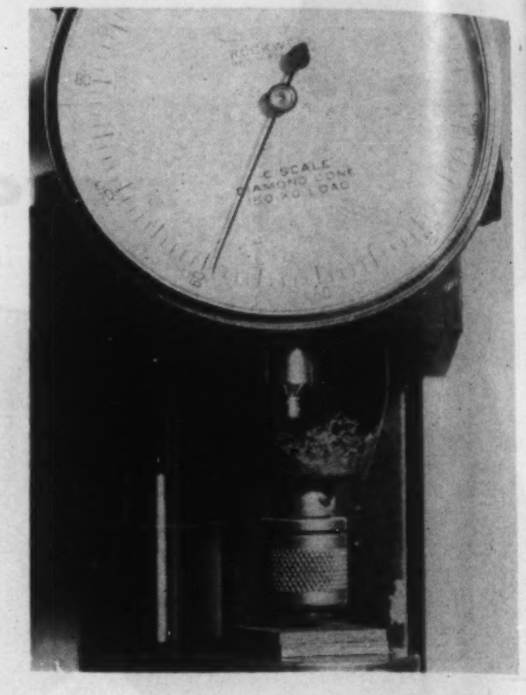
New Materials, Parts, Finishes



as gasketing, packing and facing materials as well as substituting for rubber-coated paper. Developed by *National Vulcanized Fibre Co.*, 1055 Beech St., Wilmington, Del., the fibre has a coefficient of friction 30 to 50% higher than that of standard vulcanized fibre, is about 70% more compressible, 69% more resilient and has improved chemical resistance. The accompanying table lists values comparing physical properties of the new fibre sheet material with those of standard vulcanized fibre.

Not just a coating

Hycar-type synthetic rubber can be precipitated directly on individual paper fibers, providing a uniform dispersion of the elastomer throughout the fibre sheet. Thus, the material is particularly well suited for abrasion-resistant applications since there is no coating which can wear off. Neither its fibre nor rubber components are appreciably affected by oil, making it suitable for gasketing various types of pumps. National's RS grade fibre is available in thicknesses from 0.015 to 3/8 in. thick. NEMA standards for sheet sizes and thickness tolerances apply.

(More New Materials on p. 150)

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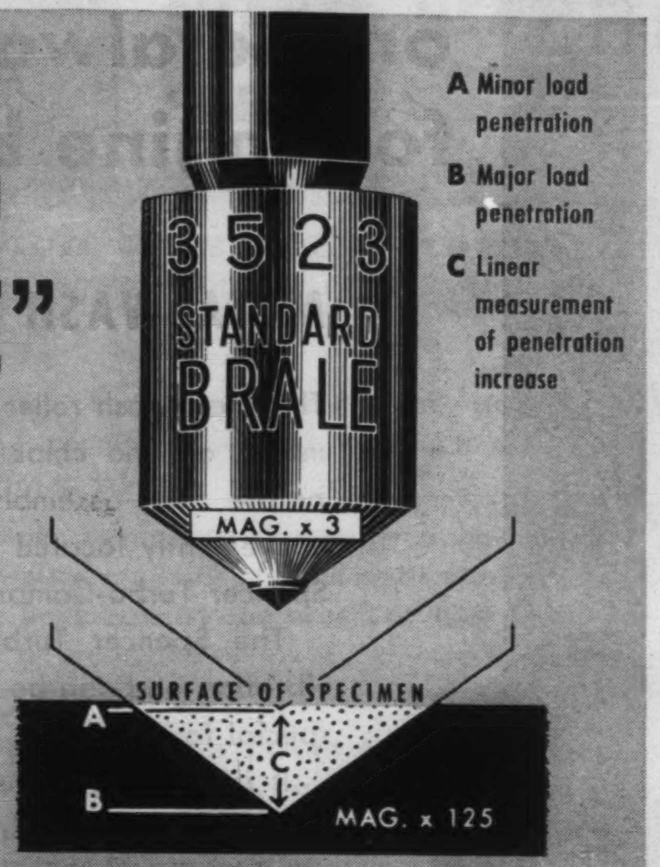

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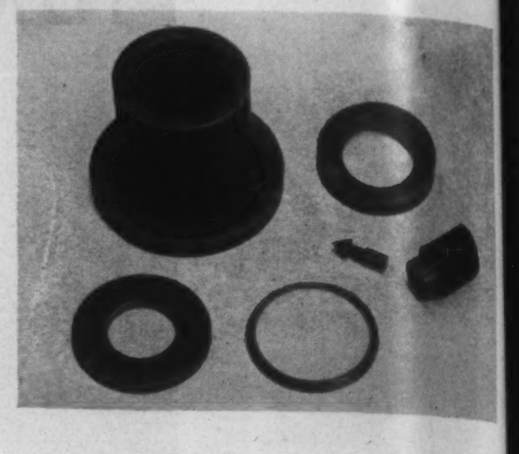
New Materials, Parts, Finishes

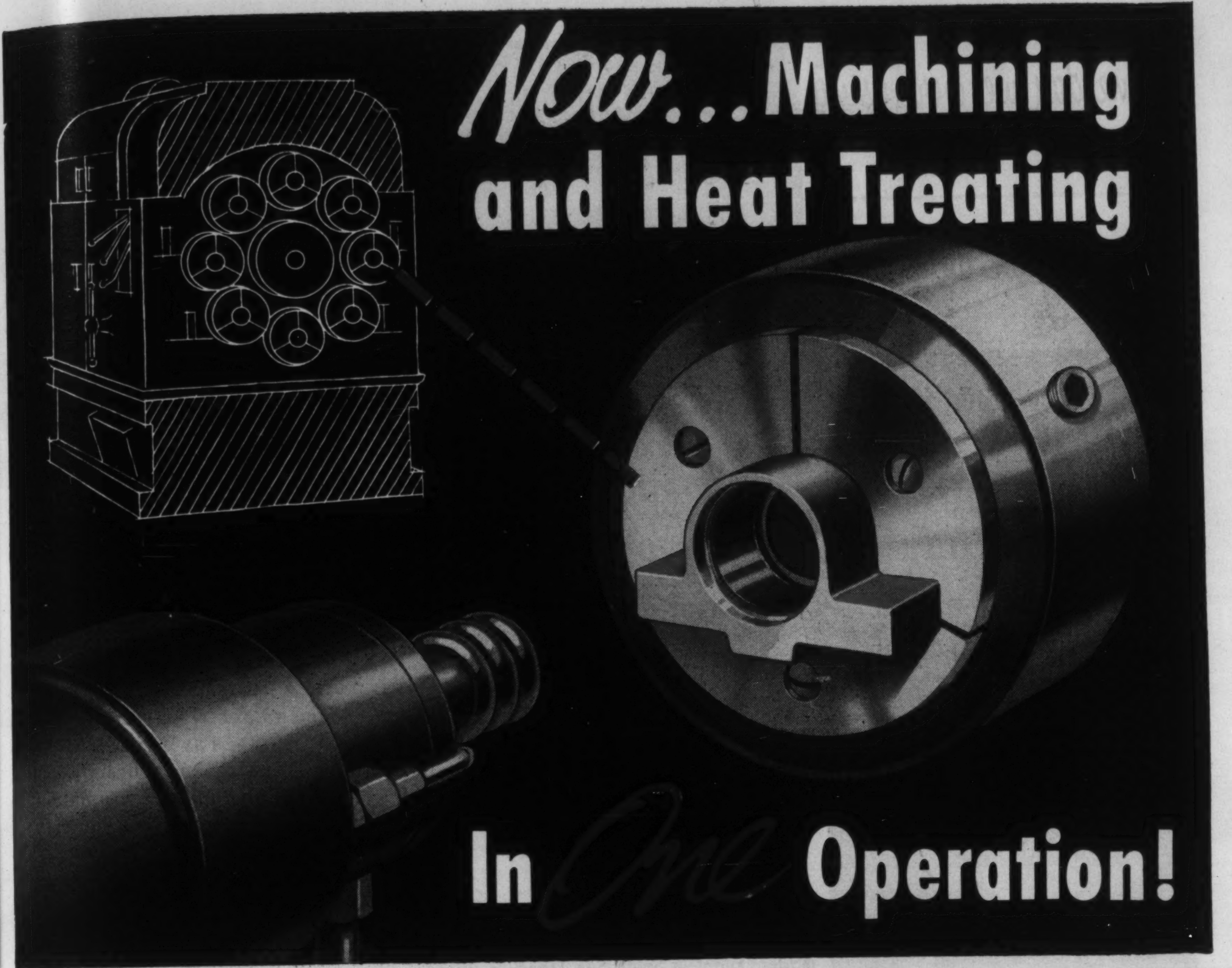


Chlorinated Polymer Combines Strength, Chemical Resistance

A new chlorinated polymer is said to provide an unusual combination of high mechanical strength, temperature resistance, chemical resistance and good dimensional stability. According to The *Polymer Corp. of Pennsylvania*, Reading, Pa., properties of their new resin fall somewhere between those of nylon and the fluorocarbons. The accompanying table lists typical properties of Polypenco K-51. The resin is brown and reportedly offers better dimensional stability than standard nylon formulations and

PROPERTIES OF K-51

Tens str at 73F, psi	6,000
Tens str at 212F, psi	3,500
Tens mod at 73F, psi	160,000
Tens mod at 212F, psi	90,000
Elong at 73F, %	60-160
Flex str (beam) at 73F, psi	5,000
Flex mod at 73F, psi	127,000
Comp str at 1% offset, psi	8,800
Comp mod, psi	130,000
Heat distortion, F	
5 x ½ x ½ in. bar-264 psi	185
5 x ½ x ½-in. bar- 66 psi	300
Izod impact (notched) at 73F, ft lb/in. notch	0.4
Hardness at 73F, Rockwell	R100
Deformation under load at 122F and 2,000 psi, %	1.4
Flammability	self-extinguishing
Therm coeff of lin exp	ca. 1.2 x 10^{-4}
Water absorption, %	0.01
Dissipation factor	
60 cycles	0.007
10^3 cycles	0.0085
10^6 cycles	0.012
Dielectric constant	
60 cycles	3.1
10^3 cycles	2.9
10^6 cycles	2.9
Volume resist, ohm-cm	4 x 10^{15}
Dielectric str, v/mil	400



Now... Machining and Heat Treating In One Operation!

with TOCCO Induction Heating

Mechanics Universal Joint Division of Borg-Warner Corporation now combines automatic heat-treating and metal-working operations on the same machine!*

A Tocco Inductor Coil, matched to one spindle of a multiple spindle automatic screw machine, heat treats the inside diameter of automotive trunnion cups—after they have been completely formed on the same machine tool. Twenty-two, 20 and 50 kw, 450,000 cycle TOCCOtron Induction Heating units and 44 automatic screw machines (installed here and in other plants) make up this high-speed production team.

This new method permits the use of SAE 1144 steel and eliminates costly, time-consuming copper plating and carburizing operations formerly required. Heating and quenching cycles total approximately 10 seconds per part, and production is in excess of 300 parts per hour from each machine.

If your products or their components require heat treating, soldering, brazing or forging it will pay you to investigate TOCCO for better, faster ways of producing them at lower unit cost.

Write for free catalog—**TOCCO Induction Heating.**

THE OHIO CRANKSHAFT COMPANY
Dept. T-9, Cleveland 1, Ohio

TOCCO
JUST PUSH A BUTTON

*SEE this application in operation at
Cone Automatic Machine Co.
BOOTH 401
National Machine Tool Builders' Show
CHICAGO—Sept. 6-16.

For more information, turn to Reader Service Card, Circle No. 364

"One day we were using 14 hand sprayers ...the next day, 2

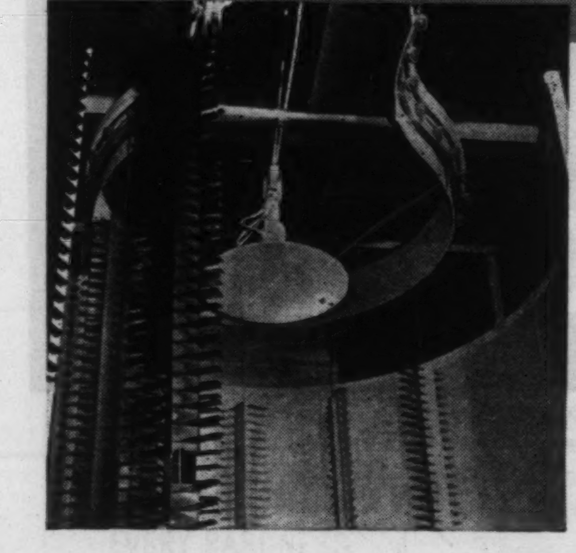
"One day we were using 180 gallons of paint ...the next day, 75

"Fantastic?" Not exactly. It's a typical, on-the-job-example of the savings made possible with the

RANSBURG NO. 2 PROCESS

Electrostatic Spray Painting

And, in this instance* production was increased; quality of the work improved, and rejections cut to practically nothing.



*Fluorescent Fixtures of California, in their modern plant in South San Francisco, uses the Ransburg No. 2 Process Reciprocating Disc Atomizer to paint their popular line of ALL-BRITE lighting fixtures. The quotes above are from Works Manager, R. H. Shaffer.

Regardless of the type of product you manufacture, if it's painted . . . and, if your production justifies conveyorized painting, you should look into the savings (and improved quality) which can be yours with one of the Ransburg Electrostatic Painting Processes. May we tell you about complete Ransburg services?

Write Dept. M

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

For more information, turn to Reader Service Card, Circle No. 304

New Materials, Parts, Finishes

fluorocarbon plastics now available. It is less expensive than the fluorocarbons. It exhibits no cold flow and unusual resistance to changes due to internal strains. It has zero water absorption. K-51 has a heat distortion temperature of 185 F for 264 psi and 300 F for 66 psi, but it is not recommended for continuous use at temperatures above 250 F unless in a non-oxidizing atmosphere. The chemical and heat resistance of the polymer are said to make it ideal for end uses at 212 to 250 F temperatures which could be handled previously only by more expensive materials.

The material effectively resists such reagents as hydrochloric, sulfuric, nitric, and chromic acids, acetone, acetophenone, ammonium hydroxide, furan, anilene, ethyl acetate, ethyl ether, ethylene dichloride, heptane, toluene, hydrogen peroxide, lemon oil in alcohol, and distilled water. Mechanical properties of the material are generally good at room temperature and boiling temperatures. Essentially the same tensile strength and hardness are exhibited after one year of exposure to outdoor weathering. According to Polymer Corp., the material is harder, lighter and more machinable than fluorocarbon plastics. Though not a high frequency dielectric, K-51 has loss factors low enough to make it useful as a general purpose insulator through a wide range of frequencies.

The material is currently available in rods up to 2 in. in dia. Eventually it will be supplied in strip, slabs, tubing and rods of larger diameter.

Alloy Welding Flux for Low Alloy Steels

A new line of agglomerated fluxes has been marketed for automatic submerged arc welding of low alloy steels. The fluxes contain alloying elements which can be altered as required by the

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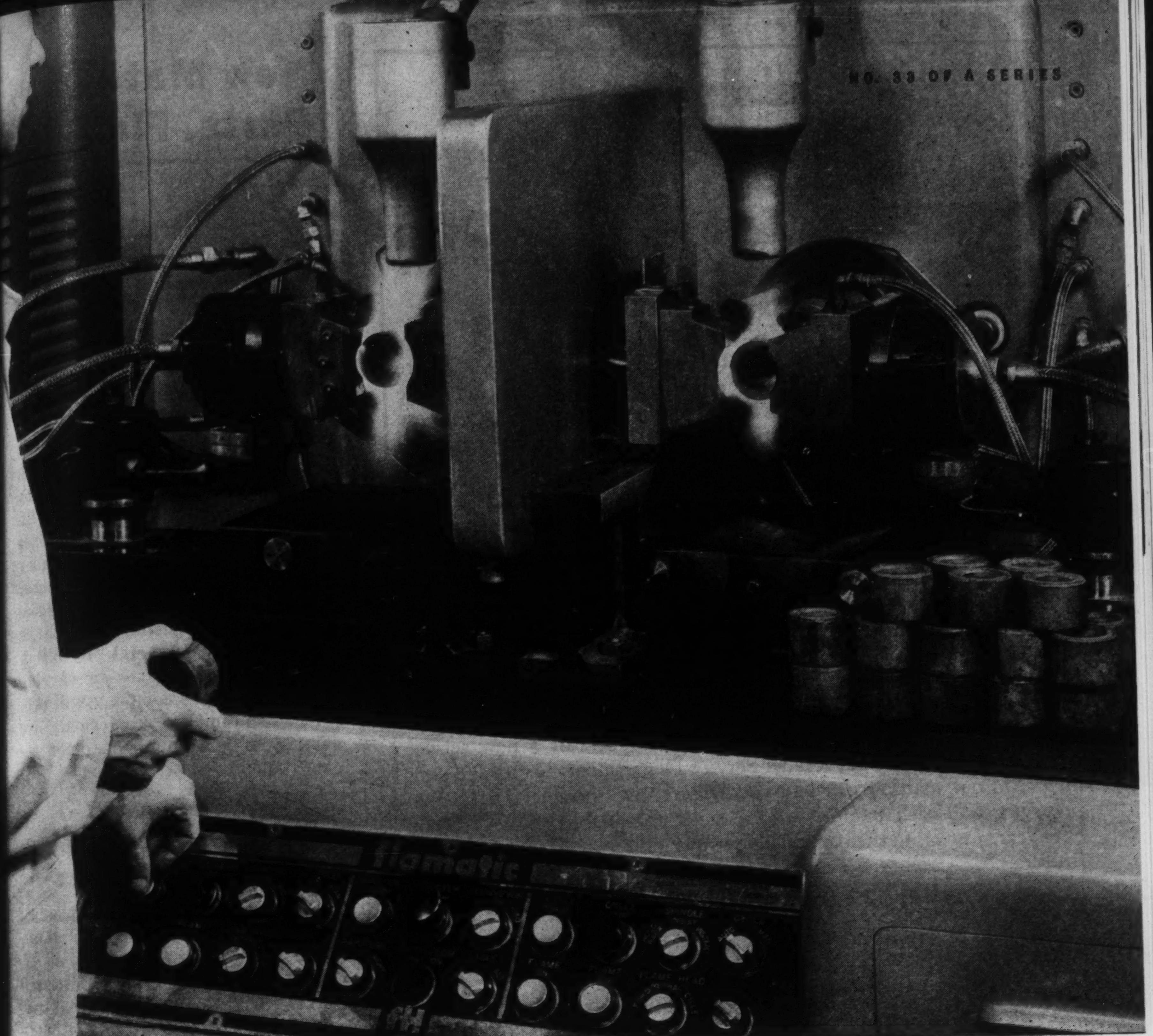

Chrysler saves 10 operations

with flamatic hardening—Imagine the drop in unit costs when you save ten operations on one part, including plating, straddle facing and turning, re-broaching, carburizing, tempering, two washings, and three inspections.

All these operations were found unnecessary as a result of one decision at Chrysler Corporation's Highland Park plant: to switch to Cincinnati Flamatic for hardening the OD of this torque converter overrunning clutch hub.

A review of your own operations may reveal an opportunity for similar savings with Cincinnati Flamatic selective hardening. If you'd like to learn about other types of operations, from job lot to line production, write for Publication No. M-1861.

CINCINNATI **flamatic**

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THE CINCINNATI MILLING MACHINE CO.
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particular job. They can be used with a mild steel electrode to produce a low alloy deposit in which chromium, molybdenum, vanadium and nickel can be varied. Applications would include welding chromium-molybdenum pipe for high temperature service; steels such as ASTM Spec A335-53; alloys P-2, P-3, P-3b, P-11, P-12, P-21 and P-22; and Spec A301-53, grades A and B. Developed by *Lincoln Electric Co.*, 22801 St. Clair St., Cleveland 17, the fluxes can be used to produce an alloy deposit that will respond to heat treatment producing the same hardness or tensile strength as that of the base metal. By blending basic alloy fluxes in varying proportions the company will produce automtic submerged arc fluxes to individual customer requirements.

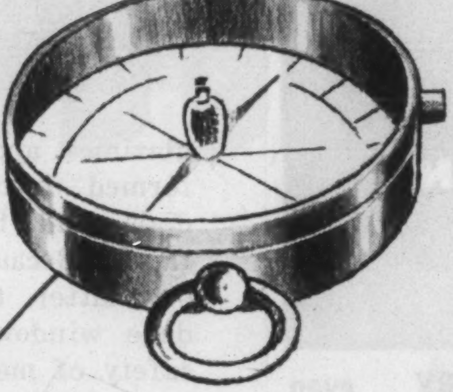
Thermoplastic Has Improved Properties

A new clear thermoplastic, Dura-lite, is said to have abrasion resistance 5 times that of ordinary methacrylate, flexural strength nearly twice that of methacrylate, and improved tensile and impact strength. A modified methacrylate, Dura-lite was developed by the *Homalite Corp.*, 15 Brookside Dr., Wilmington 166, Del. It resists crazing, has good formability and machinability and is immune to most corrosive chemicals and severe weather conditions. Dura-lite is said to be particularly well suited to most

TYPICAL PROPERTIES OF DURA-LITE

Spec Gravity, 77 F	1.22
Tens Str, psi	9200
Flex Str, psi	30,000
Mod, 10^5 psi	3.2
Impact Strength,	
Notched Izod, ft-lb/in. notch	0.4
Unnotched Izod	5.9
Heat Distortion, 10 mil, F	150
Water Absorption, %, 24 hrs at 77 F	0.2
Crazing (LP-406A)	None
Chemical Resistance	Good

THE RIGHT DIRECTION



Wolverine customers are never at sea when it comes to selecting the right tube for a specific job.

To help them steer clear of corrosion hazards, for example, Wolverine provides tubing in a wide range of sizes and alloys in copper, aluminum, electric-welded steel and bi-metal. Other "on course aids" are complete fabrication facilities and the skilled assistance of the highly trained tubing technicians in Wolverine's Field Engineering Service.

Yes, when you specify Wolverine products you are always heading in the direction of true economy. For complete information write for Wolverine's General Products Catalog.

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DIVISION OF CALUMET & HECLA, INC.
Manufacturers of Quality Controlled Tubing
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PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

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- ALLOY 20
- INCONEL
- MONEL
- PRECIPITATION HARDENING GRADES
- 0.03 MAX. CARBON

YOU GET FAST DELIVERY... even on small orders of special alloys... Hastelloy B & C, Monel, Inconel, Alloy 20, 0.03 Max. Carbon, Precipitation Hardening Grades are just a few examples of alloys that are available—fast—when you need them. No waiting for long runs of standard production items to be completed before your order can be started. Big orders can be handled efficiently and economically too. A complete metallurgical laboratory enables *ESCO* to take advantage of the latest technological advances. Result: Outstanding quality control on every order.

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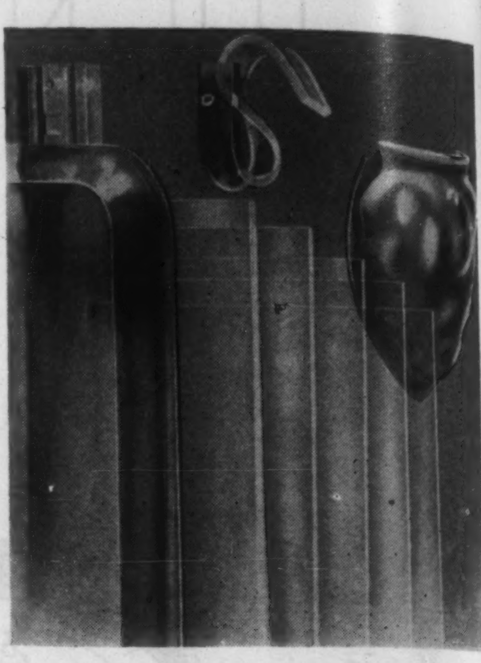
New Materials, Parts, Finishes



glazing applications such as formed instrument panels and dials and television and clock faces. Because it does not chip or shatter, the material can reduce window breakage, increase safety of men and materials and lower maintenance costs. It provides a good transparency for use as a hood or shield covering dangerous machines and harmful chemical vats. It is available in sheets, 1/6, 3/32, 1/8, 3/16 and 1/4 in. thick and in standard sheet sizes up to 40 x 50 in.

Cross-Linked Vinyl Coat

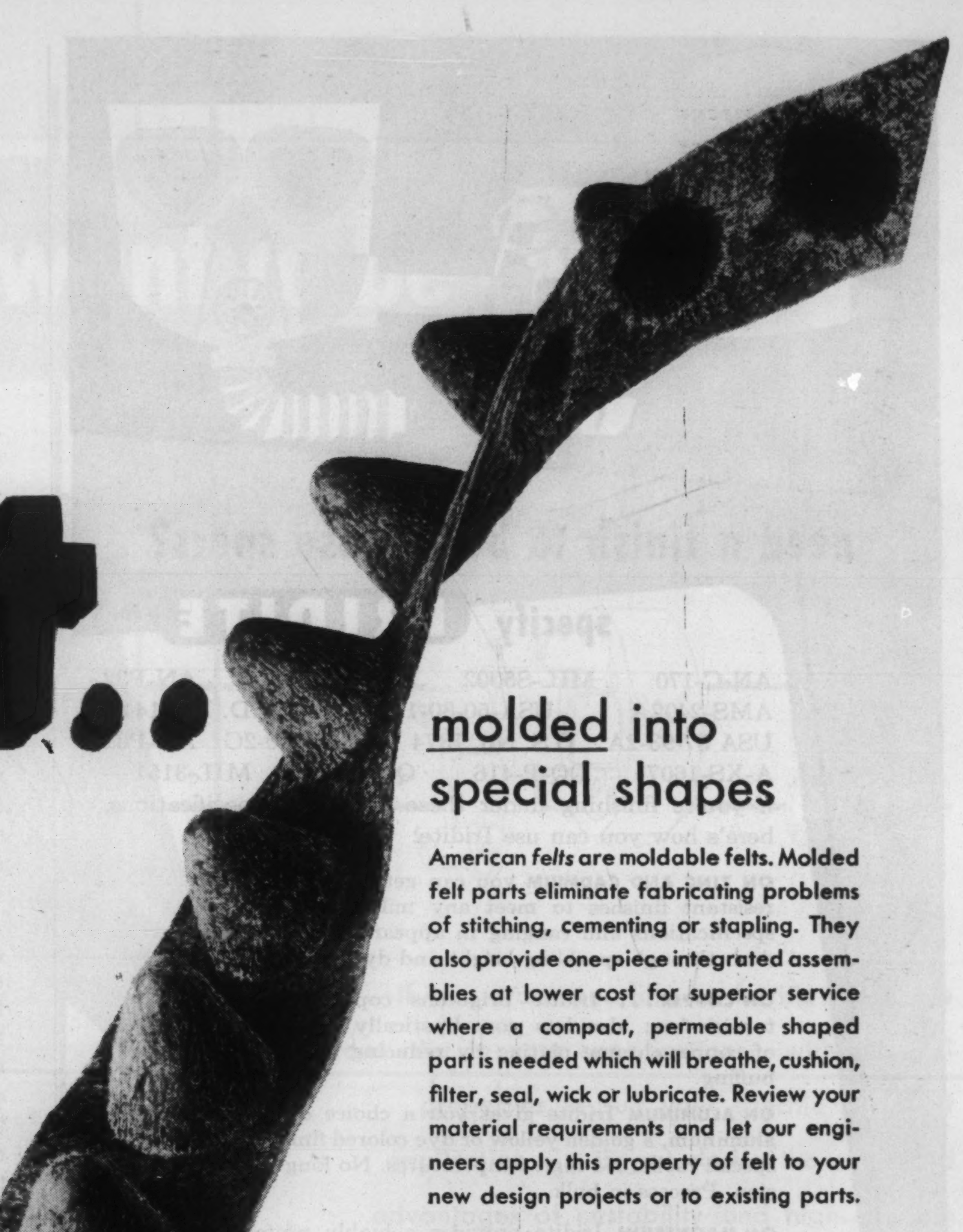
A new cross-linked vinyl coating is said to retain all the desirable properties of vinyls but offer improved adhesion, toughness and film integrity. Specifically formulated for roller coating, the so-called 13-809 White coating has been developed by *Watson-Standard Co.*, 231 Galveston Ave., Pittsburgh 12, Pa. It is furnished at 40-42% solids with a viscosity of 85-95 sec (No. 4 Ford Cup) and a specified bake temperature of 350-400 F. Available in colors as well as white, the coating is said to be particularly well suited for use on caps, closures, trays, canisters, and as strip coating and similar applications where ease of application and chemical resistance are basic requirements.

(More New Materials on p. 158)

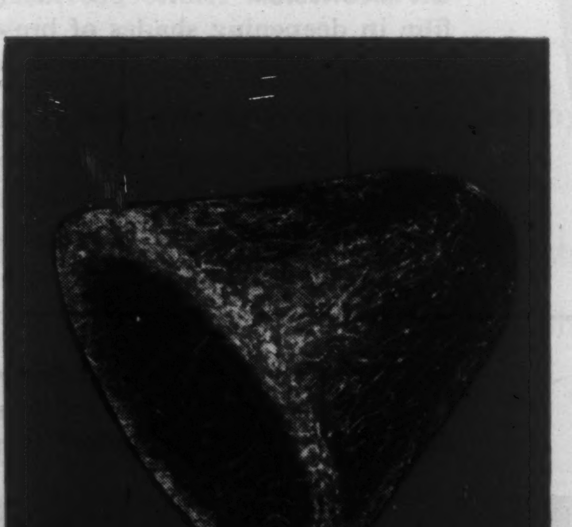
felt..

molded into special shapes

American *felts* are moldable felts. Molded felt parts eliminate fabricating problems of stitching, cementing or stapling. They also provide one-piece integrated assemblies at lower cost for superior service where a compact, permeable shaped part is needed which will breathe, cushion, filter, seal, wick or lubricate. Review your material requirements and let our engineers apply this property of felt to your new design projects or to existing parts.



Strip of felt from the molding press



Actual molded felt part as delivered to a customer.

American Felt Company

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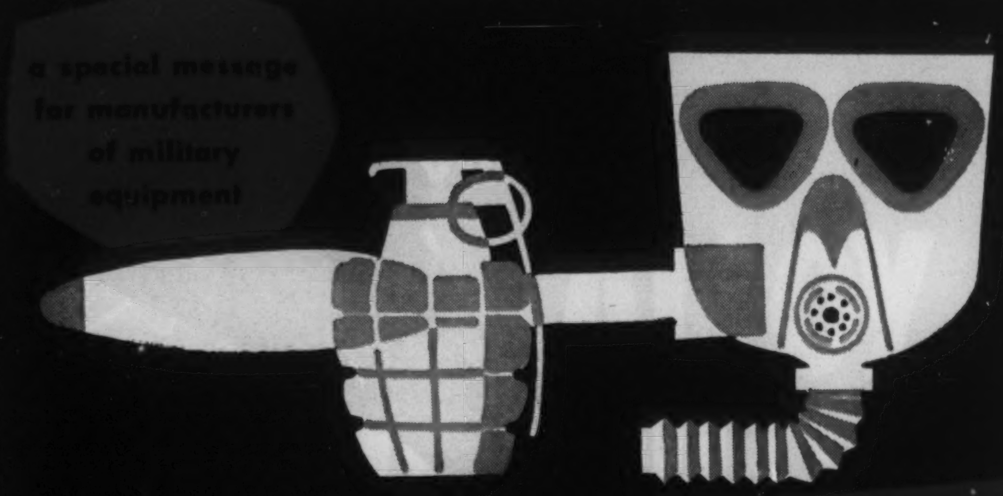
WRITE for our recommendation of a molded American Felt part to your specifications.

For more information, turn to Reader Service Card, Circle No. 342


a special message for manufacturers of military equipment

need a finish to beat these specs?

specify **IRIDITE**

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if you're finishing under these or similar specifications, here's how you can use Iridite:

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals, ARP Plating Chemicals.
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For more information, turn to Reader Service Card, Circle No. 321

New Materials, Parts, Finishes

Steel Tubing Has Smooth Interior

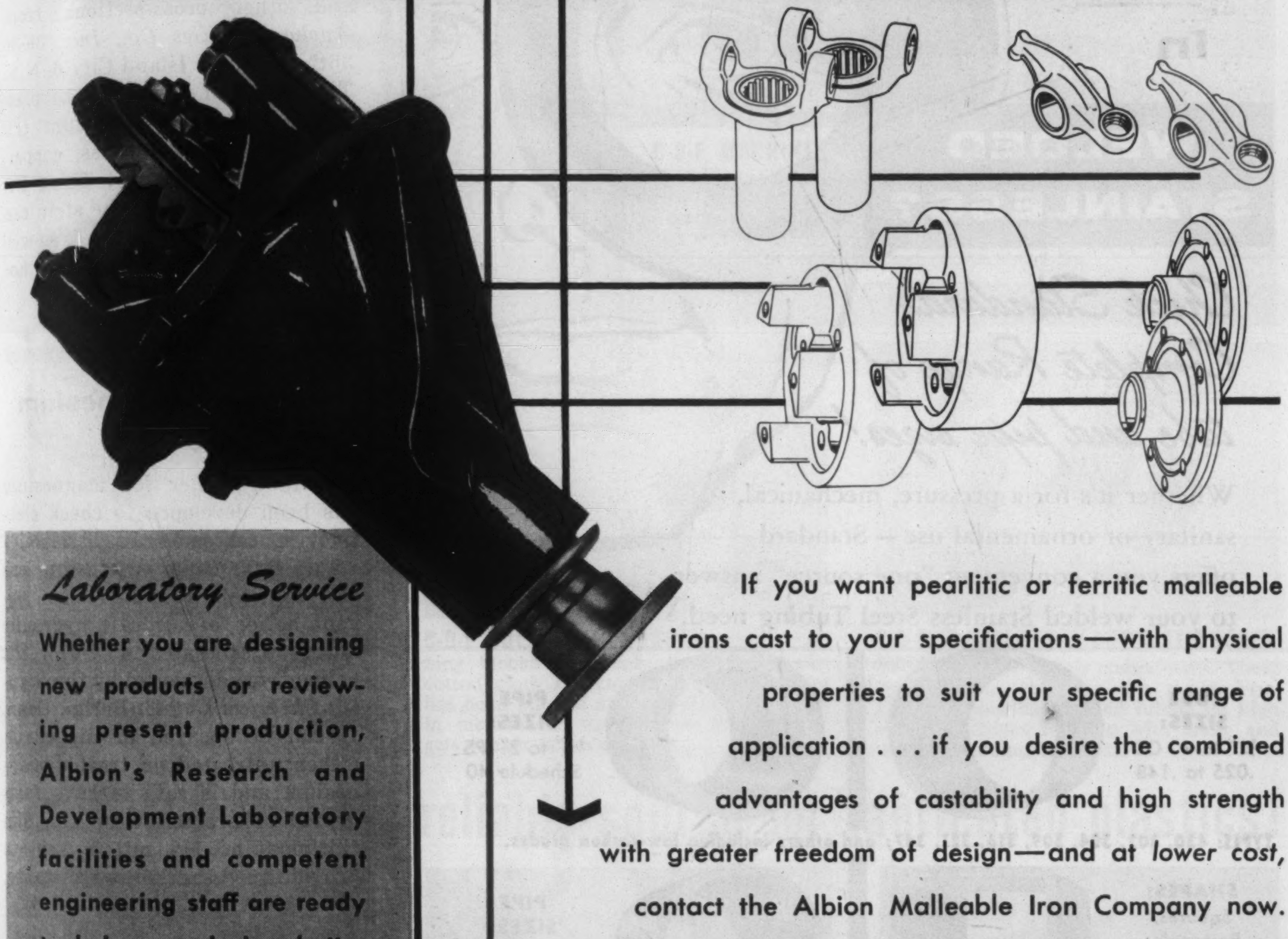
An inside surface finish superior to many honed finishes is claimed for cold-drawn welded steel tubing being produced by *Jones & Laughlin Steel Corp.*, 3 Gateway Center, Pittsburgh 30. The high surface finish is said to provide economies when used for hydraulic and pressure cylinders of various kinds. Cold drawing improves the finish, increases tensile strength and improves dimensional accuracy of the tubing. It can carry high torsion loads and resists high-frequency vibration, as well as having a favorable strength-to-weight ratio in applications in which loading is in all directions.

For high interior finish and close control over dimensional tolerances, J&L simultaneously draws the tubing over a mandrel and through a ring die. For applications calling for close control of o.d. only, tubing is sink drawn, that is drawn through the die but not over the mandrel. Minimum tensile strengths on sink drawn tubing range up to 70,000 psi and minimum yield strengths 55,000 psi, depending on size of tubing and carbon content of the steel. Tubing drawn over a mandrel is supplied to minimum tensile strengths up to 70,000 psi and minimum yield strengths ranging up to 65,000 psi. Both tubing is being produced in o.d. sizes ranging from ¾ to 2¾ in. with wall thicknesses ranging from 0.035 to 0.134 in.

Plastics Extruded Over Metal Strip

Thermoplastic cellulose acetate butyrate resins are now being extruded with embedded strip aluminum to serve as decorative trim strips or functional molding for use wherever attractive appear-

If you want to be certain



Laboratory Service

Whether you are designing new products or reviewing present production, Albion's Research and Development Laboratory facilities and competent engineering staff are ready to help you design better products that can be made at lower cost.

If you want pearlitic or ferritic malleable irons cast to your specifications—with physical properties to suit your specific range of application . . . if you desire the combined advantages of castability and high strength with greater freedom of design—and at *lower cost,* contact the Albion Malleable Iron Company now. They will be glad to bring you up-to-date on the rapid development in Albion's modern casting techniques which offer engineering advantages that are yours—*if you want to be certain.*

Remember . . . there is no engineering substitute for good, accurate, dependable castings!

ALBION MALLEABLE IRON CO.
ALBION, MICHIGAN

For more information, turn to Reader Service Card, Circle No. 508

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THE STANDARD TUBE CO.
Detroit 28, Michigan
Welded Tubing Fabricated Parts
STANDARDIZE with STANDARD — It Pays

For more information, turn to Reader Service Card, Circle No. 467

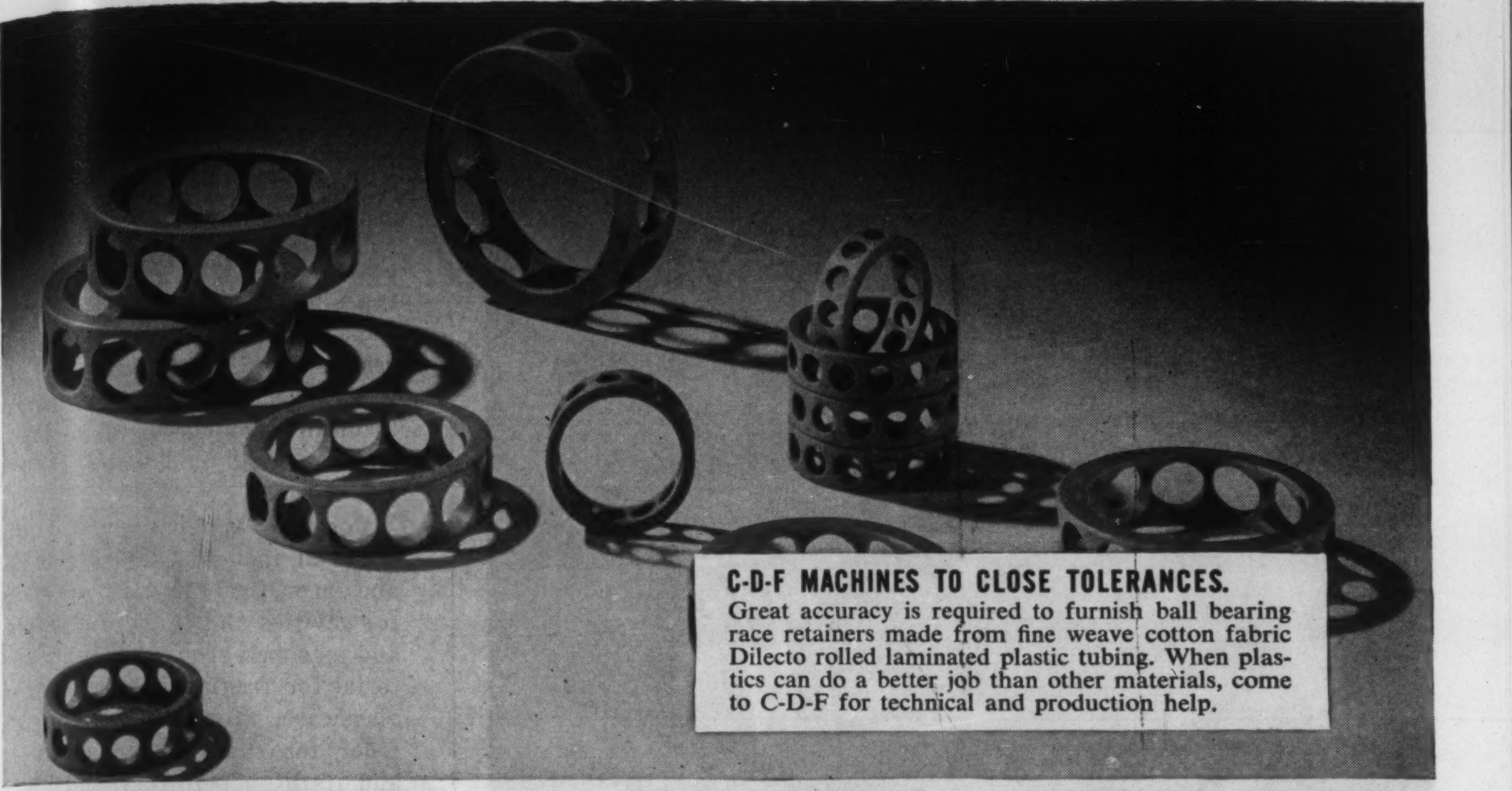
ance is important. The aluminum strip is completely protected by the plastics from wear or corrosion. Extrusions are available to specifications in U, H, L, T, V, E, and other cross-sections from *Anchor Plastics Co., Inc.*, 36-36 36th St., Long Island City 6, N.Y. The range of colors of the plastics resin lends aluminum the luster of polished brass, copper, silver or gold. Called Third Dimension extrusions, the strip can be bent, drilled or mitered, as well as printed, silk screened or hot stamped.

Primer for Magnesium Cuts Corrosion

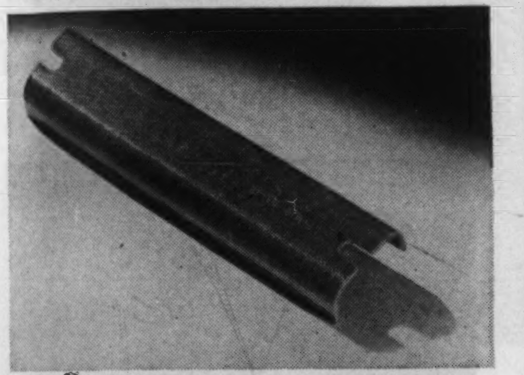
A new primer for magnesium has been developed to check electrolytic corrosion in assemblies where magnesium is joined to less active metal. It also resists solvent action of aircraft hydraulic fluids. Designated 40X-675, the primer was developed by the *Stanley Chemical Co.*, E. Berlin, Conn. It can be sprayed or dipped on either untreated or treated magnesium and is said to have fast-drying characteristics. A film thickness of 1½ mil is said to provide good salt spray resistance.

Spray or Pour New Foam Plastics

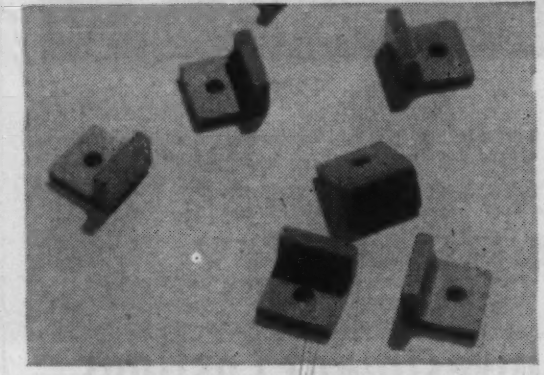
A two-package system of polyurethane (isocyanate) foaming resins which can be sprayed or poured to coat surfaces or fill voids has been marketed by *Surface Chemicals, Inc.*, 1101 Thompson Ave., McKees Rocks, Pa. The resin and catalyst are pre-mixed with metering equipment, precluding the need for heat or pressure to foam the plastics. Resins can be expanded to densities ranging from 3 to 15 lb per cu ft. According to Surface Chemicals,



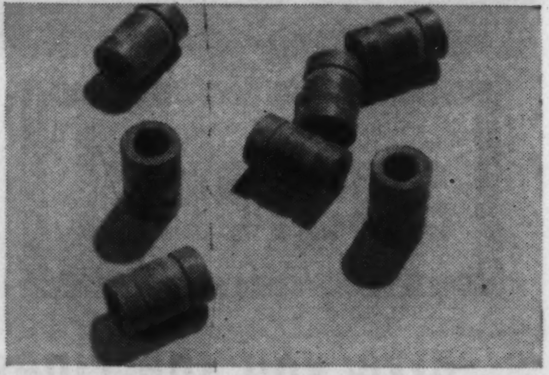
C-D-F MACHINES TO CLOSE TOLERANCES. Great accuracy is required to furnish ball bearing race retainers made from fine weave cotton fabric Dilecto rolled laminated plastic tubing. When plastics can do a better job than other materials, come to C-D-F for technical and production help.



C-D-F PIONEERED IN POST-FORMING of laminated plastics. This technique gives you stronger, more versatile insulating parts with lower costs. This aircraft channel strip is an example of simple post-forming.

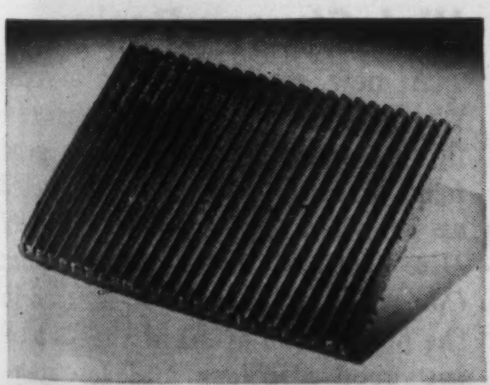


C-D-F DOES THE UNUSUAL. These rubbing blocks are made from fine-weave cotton cloth Dilecto molded *tubing* that has been pierced and cut. The part gains in mechanical strength — the product gets longer service life.

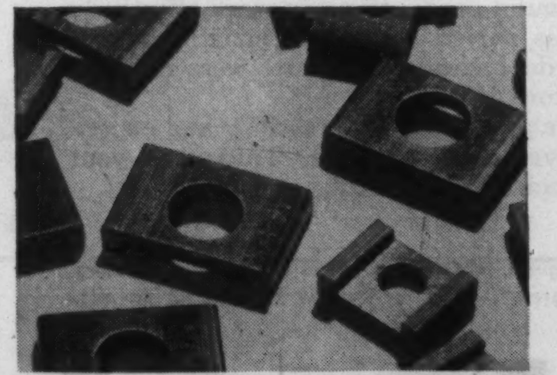


C-D-F SPECIALIZES IN AUTOMATIC SCREW MACHINING of plastic components. These breaker arm bushings are made from Dilecto paper base rolled tubing on high speed machines by men who know and use cost saving methods.

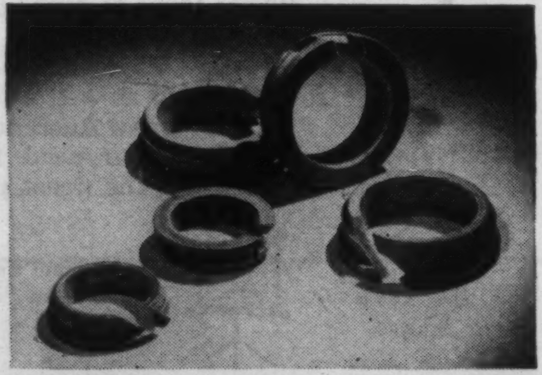
Yes, C-D-F is a big reliable source for fabricated plastics!



C-D-F SERVES MANY INDUSTRIES with fabricated specialties. A great amount is concentrated in the automotive and allied fields. This aircraft part has a corrugated surface on a strong woven asbestos laminated base.



C-D-F IS A PUNCHING SPECIALIST on these starter solenoid insulators. This is XX-26 Dilecto molded channel strip, pierced and punched to length. Special C-D-F punching grades give you lower costs, faster assembly, fewer rejects.



C-D-F COMES UP WITH THE ANSWERS to insulating problems. These unique snap-in grommets are easy to insert, spring out and hold tight. Write for samples. The chances are that C-D-F is already making the answer to your problem.

See our general catalog in Sweet's Design File for more technical data, the address and telephone number of your nearest C-D-F sales engineer. Also, write for detailed information, samples, or send us your print for quotation.

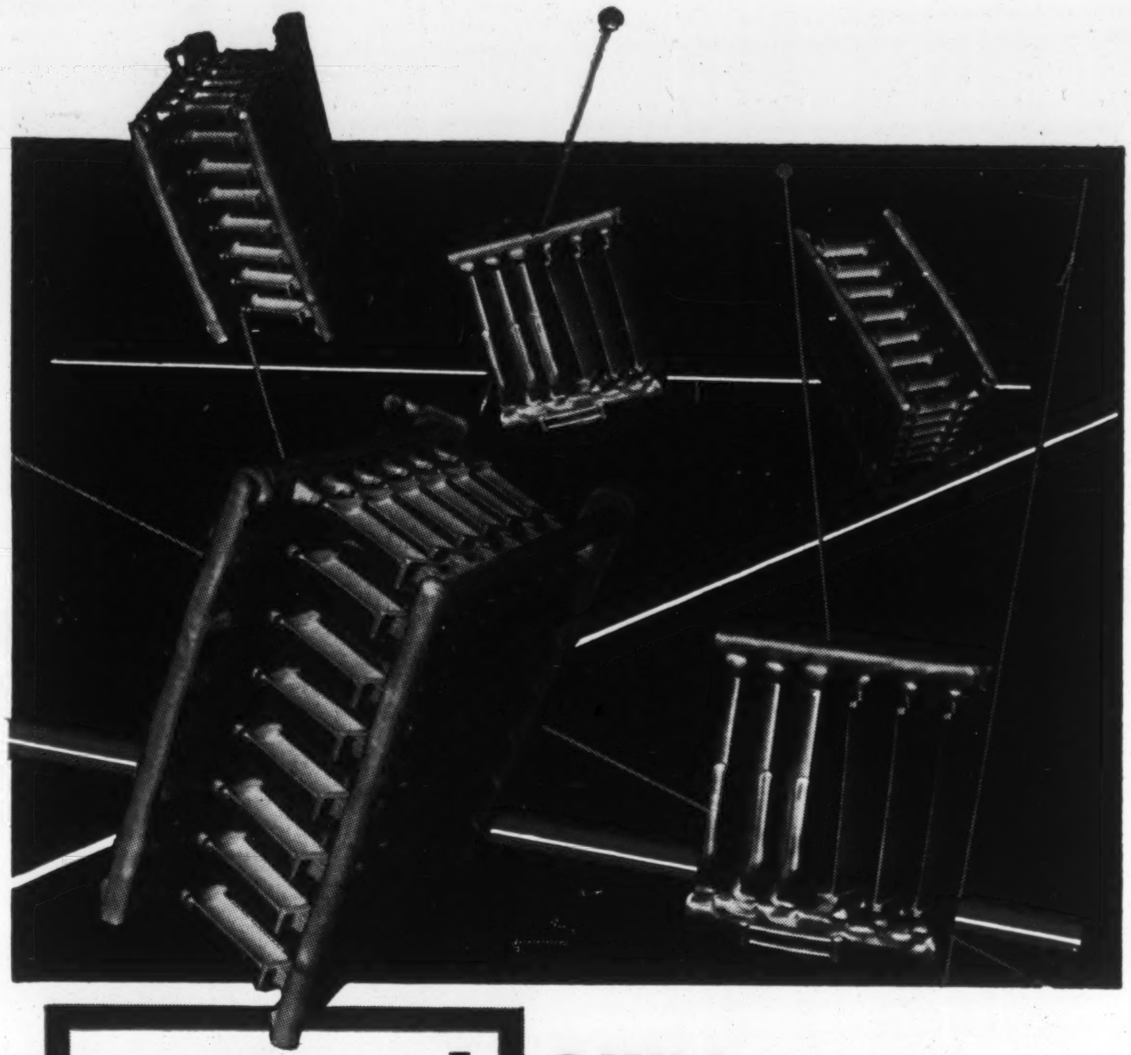
CDF

Continental-Diamond Fibre

CONTINENTAL-DIAMOND FIBRE DIVISION OF THE BUDD COMPANY, INC.

NEWARK 25, DELAWARE

For more information, turn to Reader Service Card, Circle No. 498



austenal SKILL EXPERIENCE VERSATILITY

give you the Finest Investment Castings

These are the three fundamentals of Austenal production. Only all three brought together can guarantee the finest investment-cast parts for American defense and industry.

By means of Austenal's Microcast process such exact parts as jet turbine buckets and vanes are being cast, eliminating costly machining and holding finishing to a minimum. Thus, these vital jet components are available for national defense in greater numbers and more economically than ever before.

These three factors of sound production can work effectively for industry. Austenal has solved many industrial problems where fine, accurate and dependable cast parts were required for efficiency as well as economy.

Depend upon Austenal's greater skill, versatility and experience when you need investment castings. These are your assurance of the finest precision cast parts.

See Austenal's original, informative 16mm color movie, "A Story of Industrial Progress". Write for loan of the film at no cost.

MICROCAST PRECISION CASTINGS PROCESS

austenal®
LABORATORIES, INC.
microcast division
224 EAST 39th STREET • NEW YORK 16, N.Y.
7001 SOUTH CHICAGO AVENUE • CHICAGO 37, ILL.

For more information, turn to Reader Service Card, Circle No. 511

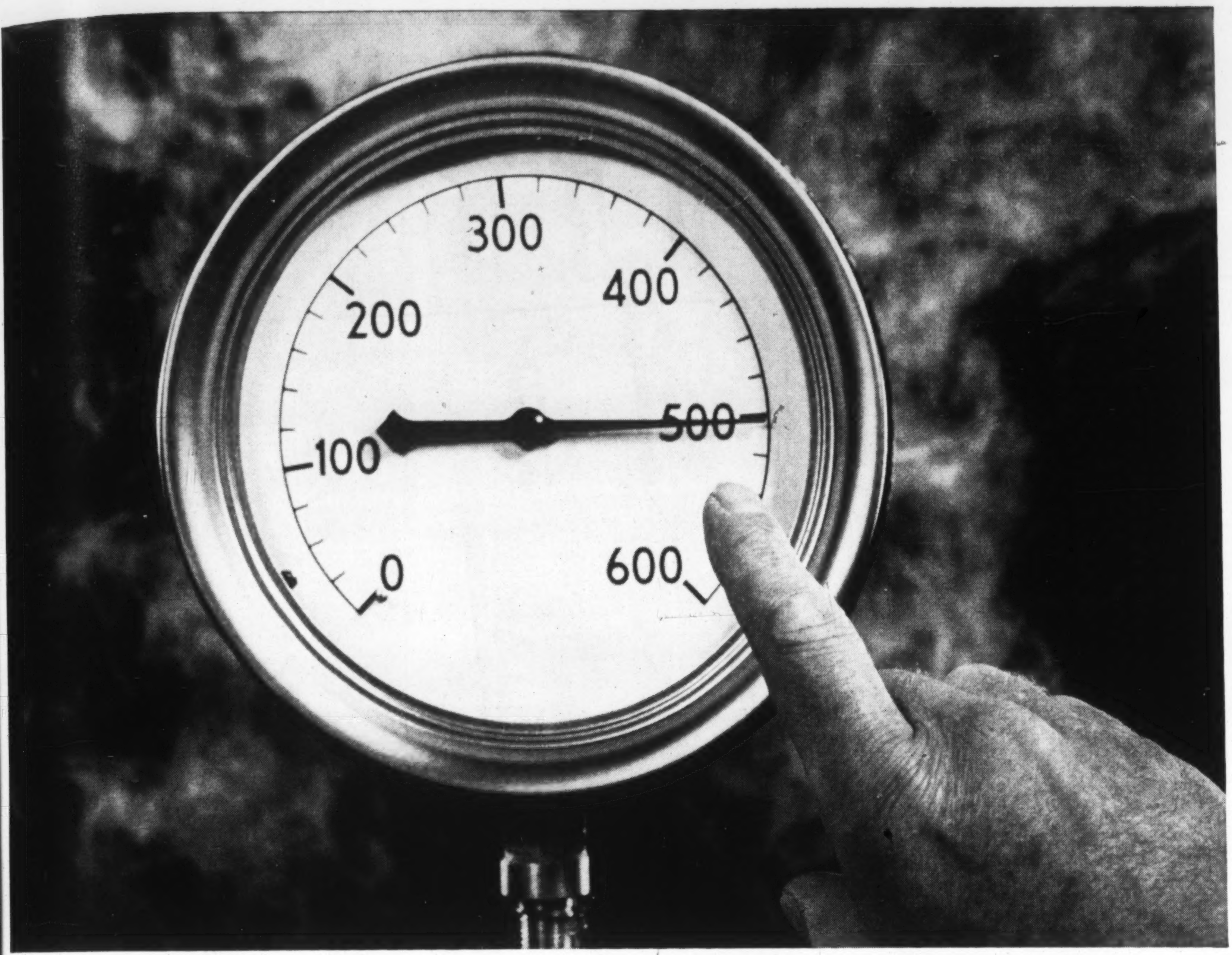
their foaming system, called Isothane, has good adhesion to all types of surfaces and has high impact, vibration, and chemical resistance. It is also said to have good dielectric properties, thermal insulating and acoustical qualities, and practically no water absorption.

Possible applications for the material include uses as thermal and acoustical insulation, fillers for cavities and voids of all types, and as shock-proof packaging material for fragile instruments and glassware. It is also a good stiffener for sandwich construction, and its high buoyancy and water resistance indicate its use for lightweight pontoons, life rafts and similar equipment.

New Modified High Styrene Resin

A new modified high styrene resin, designed as an easy processing calendering resin with good heat stability has been marketed as Plio-Tuf C75 by the *Chemical Div. of Goodyear Tire & Rubber Co.*, Akron 16, Ohio. It is used in the production of rigid sheets having good stiffness and low temperature impact strength.

Heat distortion point is 190 F at 66 psi fiber stress. Notched Izod impact values in the range of 9.0 ft-lb per in. of notch have been obtained at room temperature and about 1.5 ft-lb per in. notch at 0 F. It has good chemical resistance and can be used for a number of electrical uses. Dielectric strength is rated at 442 v per



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ON THESE FABRICS

Nylon • "Dacron"† • Glass
Cotton • "Orlon"‡ • Asbestos

Glass fabrics coated with "Teflon" tetrafluoroethylene resin, elastomer sheet stocks and cements

†Du Pont's trade-mark for its polyester fiber.
‡Du Pont's trade-mark for its acrylic fiber.

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Take the case of Mr. J., candy manufacturer. He needed a conveyor belt that could withstand the high temperature of molten peanut brittle—and have the "release" necessary for easy removal of the candy after cooling. Technicians of the Du Pont Fabrics Division developed the answer—a *coated fabric* that combined both properties.

"Fairprene" Industrial Products are a wise choice for "tough" jobs where ordinary belts, diaphragms, seals, or protective cloth materials fail prematurely. With the proper fabric and coating, you can obtain the exact combination of properties your application demands. Whether you need resistance to oil or heat . . . abrasion or flex cracking . . . there's a coated fabric that's *right* for the job.

Look into "Fairprene" Industrial Products before you start your next design. We'll be glad to discuss them with you. Just clip and mail the coupon for further information.

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, M-59, Fairfield, Conn.

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( ) Have a representative call. ( ) Send further information.

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Firm____________________

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KEYSTONE
"SPECIAL PROCESSED"
COLD HEADING WIRE

Recommended for Your DIFFICULT Cold Heading Jobs

When you have "tough-to-make" cold heading jobs on your production schedule, it will pay you to consider the outstanding advantages offered by Keystone "Special Processed" Wire.

The superior grain flow characteristics of this wire provides the necessary upsetting and die forming qualities to withstand the terrific displacement of metal during the most difficult cold heading process. The structural soundness and uniformity of "Special Processed" Wire further proves itself through trouble-free machine operation, longer die life, and finished products of the highest quality.

If you have a special wire problem . . . large or small . . . let us help you solve it. Contact your Keystone representative or write.

Keystone Steel & Wire Company
Peoria 7, Illinois
Industrial Wire Specialists

For more information, turn to Reader Service Card, Circle No. 420

New Materials, Parts, Finishes

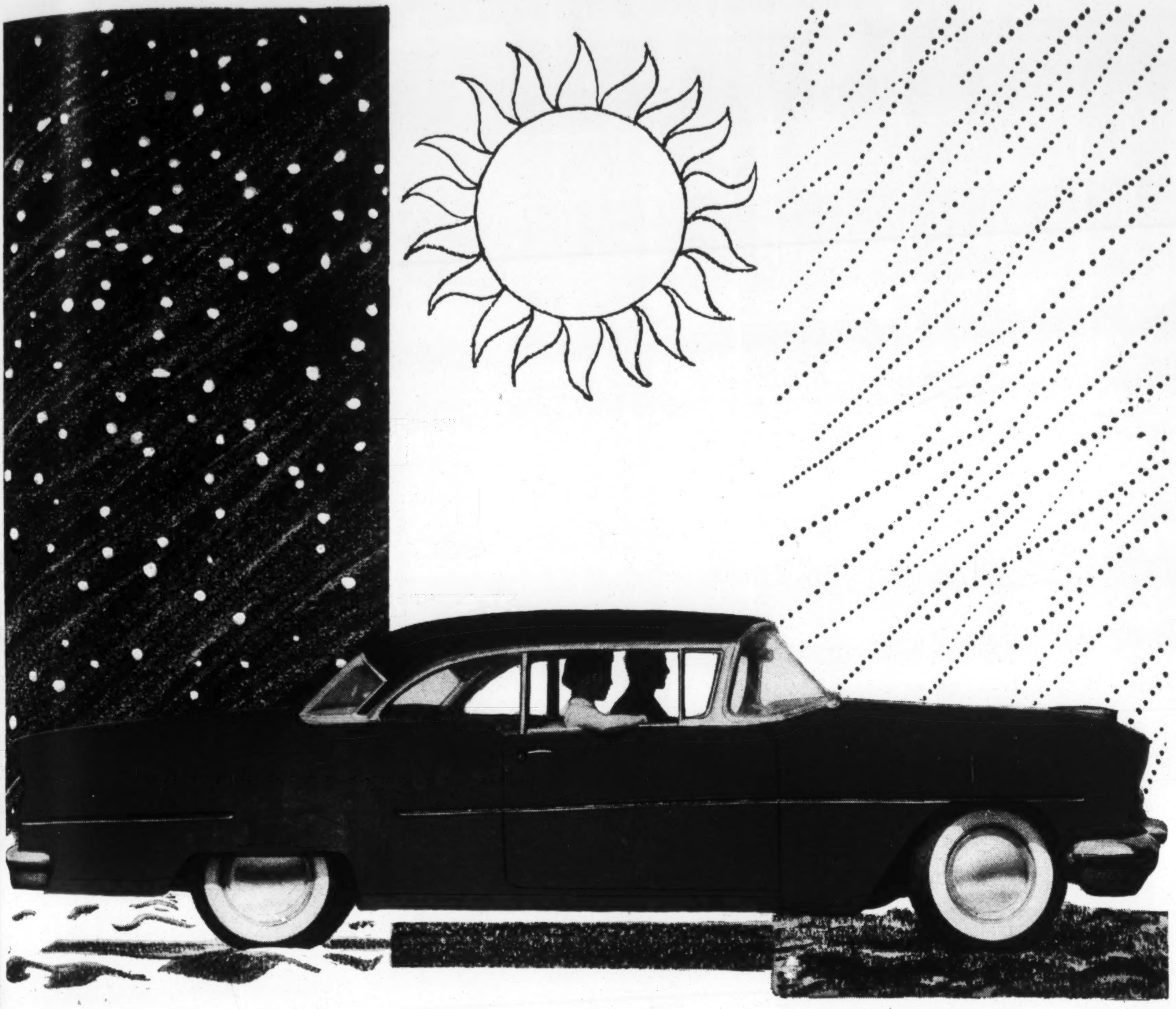
mil at 1 kc. Sheet made from the resin can be postformed by a variety of methods including vacuum draw, vacuum snapback, drape, and plug and ring forming, as well as by blow molding and line bending of sheet.

According to Goodyear, equipment necessary for processing Plio-Tuf C75 includes mixers, mills, a three or four roll calender, take-off, cutters, roll-ups or presses and molds for embossing. The resin does not require plasticizers, but loaders and fillers may be added if desired during mixing. A wide range of pigments can be used. Color or master batches are not necessary but considerably facilitate pigment dispersion. Trimmed stock from calenders can be fed directly back to the mills without regrinding and without impairing physical properties of the resins. Press lamination and embossing of calendered Plio-Tuf sheet produces a relatively strain-free material with good detail and stability of embossed pattern.

New Neoprene Coating

A new chemical- and corrosion-resistant neoprene coating formulated from Du Pont's neoprene and hardening resins can be applied directly by brush, roller, spray or dip. It is said to require no accelerator or primer and produces a coat thickness of 2 to 3 mil, drying dust-free in 30 min. It will adhere to materials such as metal, masonry, wood, fabric and rubber. Two coats with a drying time of 2-4 hr between applications are said to provide sufficient protection for most uses. It is being marketed by *Saran Protective Coatings Co.*, Ferndale 20, Mich.

The material is said to provide an acid- and alkali-resistant surface which is tough, resilient, abrasion resistant, non-oxidizing, and long wearing. It has high dielectric properties and inhibits



100 parts made from Enjay Butyl give all-weather protection to new cars

In many new models, extended "new car performance" is assured in over 100 places by parts made from Enjay Butyl. This super-durable rubber has many advantages that make it amazingly resistant to the deteriorating elements that cause the early failure of most types of rubber. Its price and ready availability are advantages, too.

If you make a product in which rubber is used, or *might* be used, why not contact the Enjay Company? Our technical consultants might have very good news for you about the use of Enjay Butyl in your product. News about lower costs and higher efficiency. Why wait?

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY **ENJAY COMPANY, INC.,** **15 West 51st Street, New York 19, N. Y.**
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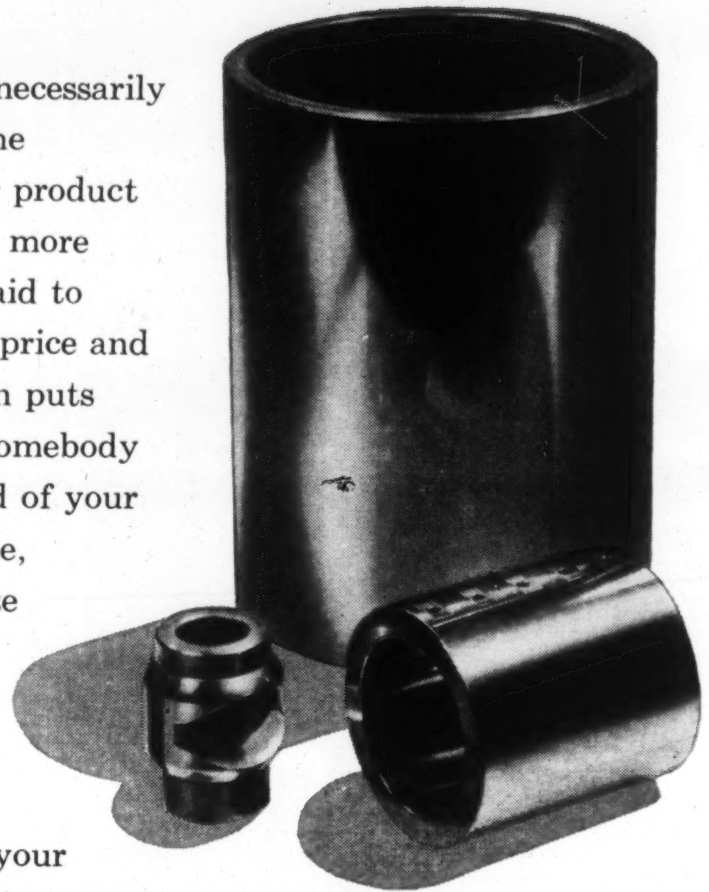
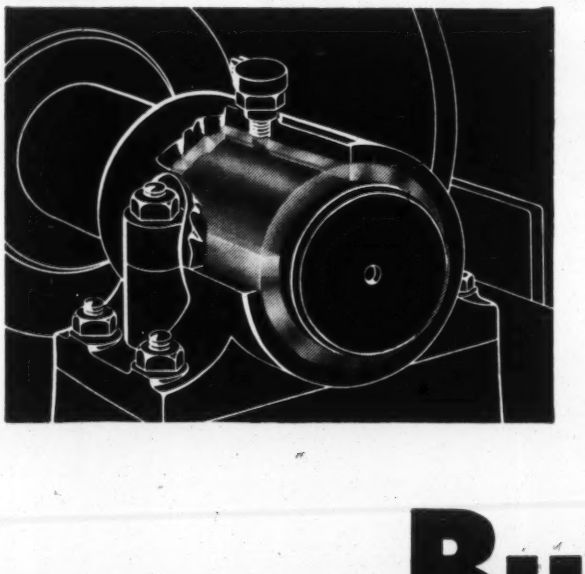
GIVE YOU

Competitive Advantages

Employment of an unnecessarily expensive bearing for the "prestige" it gives your product sometimes proves to be more of a handicap than an aid to sales. It increases cost, price and service expense. It often puts the sales emphasis on somebody else's "prestige" instead of your own. The sturdy, simple, inexpensive Cast Bronze Bunting Bearing will give you maximum bearing performance at minimum bearing cost and permit you to sell your product on its own merits at a profitable low price.





Why not re-examine your present designs. There is a Bunting engineer near you who can give you helpful technical counsel. Or write our Product Engineering Department at Toledo.

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BRONZE BEARINGS • BUSHINGS • PRECISION BRONZE BARS
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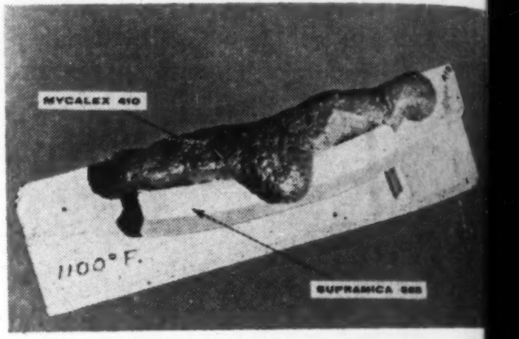
galvanic action between dissimilar metals. The coating will withstand intermittent temperatures of 350 F without damage. It is currently available in black, gray, red, green and aluminum. Neoprene is finding widespread use in chemical plants, food processing plants, dairies, breweries, oil refineries, textile mills, and plating plants as a coating for floors, walls, structural steel, tanks, ducts and processing equipment. It is also being used on hulls, decks, propellers, shafts and rudders of marine vessels.



New Insulation Good Up to 1000 F

A so-called ceramoplastic electrical insulation material consisting of pulverized synthetic mica bonded with electrical glass is said to withstand effects of radiation and temperatures up to 1000 F without losing its properties. Previous formulations made with natural mica and glass were limited to temperatures of about 700 F. Called Supramica, the material was developed by the *Mycalex Corp. of America*, Clifton, N.J.

In addition to high thermal and radiation endurance, Supramica ceramoplastic products are said to possess permanent dimensional stability, low electrical loss and high arc resistance. They are impervious to water, oil and organic solvents.

The material is available in sheet and rod form (Supramica 500) with a thermal endurance of 1000 F, or as finished components precision-molded to desired specifications (Supramica 555) with a 950 F thermal endurance.

(More New Materials on p. 168)

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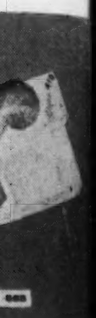

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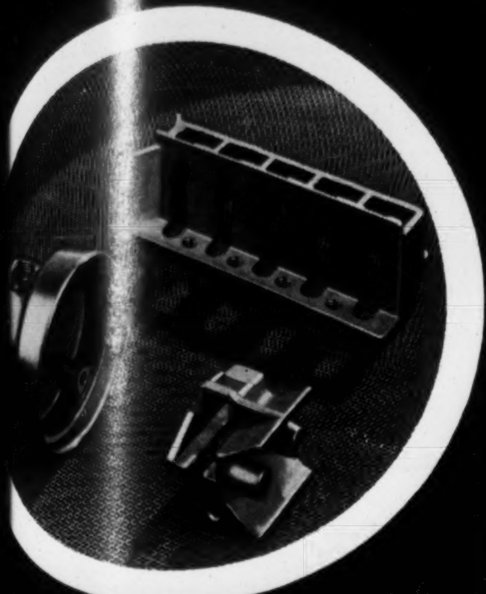
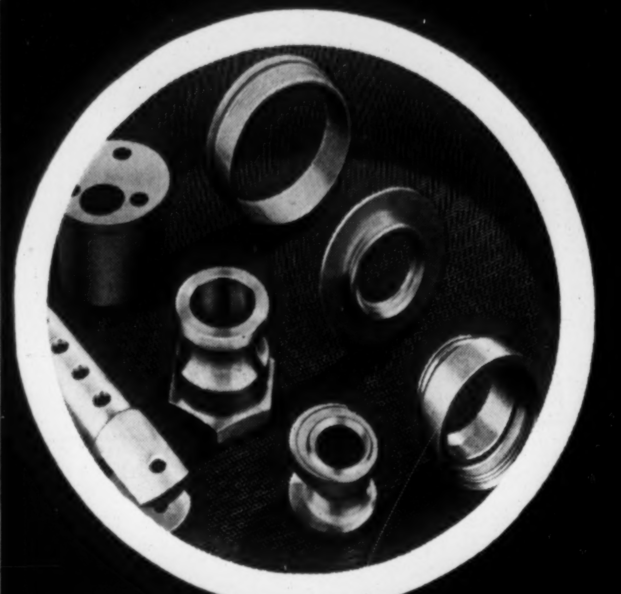


Titan brass pressure die castings

Titan brass and bronze forgings



Titan brass and aluminum hand screw machine parts

ne of Titan's mod-
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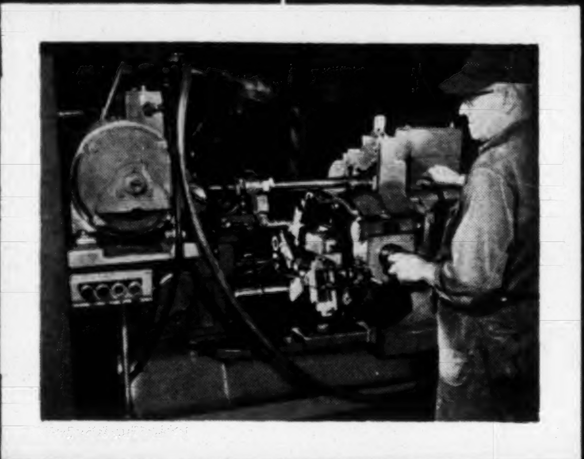

Accurately machining a Titan forging on a turret lathe. Titan fabricating operations cut customers' assembly costs.

Titan machined parts

have sparkle, economy and versatility

Appeal and usefulness of brass or aluminum forgings and pressure die castings are increased greatly by multiple drilling, reaming, tapping, gang-milling, turning, broaching or knurling at the skilled hands of Titan machinists.

Equipment includes turret lathes and automatic chucking machines for producing finished machine parts of volume, quality, economy and superb finish. For example, high-quality forgings are supplied by Titan ready for assembly—already precision-broached and gang-milled with multiple-drilled and tapped holes.

When smaller quantities of fabricated parts are needed, Titan hand screw machine facilities come into play. Here, holding to closest tolerances and precision requirements is regular practice.

Let us suggest how Titan machined parts may solve your assembly problems and cut costs. Write for more information. And send for new 40-page full-color booklet "Behind the Scenes." Use the coupon below.

Titan®

METAL MANUFACTURING COMPANY
Bellefonte, Pa. Offices and Agencies in Principal Cities

Dept. E
Titan Metal Manufacturing Co., Bellefonte, Pa.

Gentlemen: Please send 40-page booklet "Behind the Scenes."

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Waterbury

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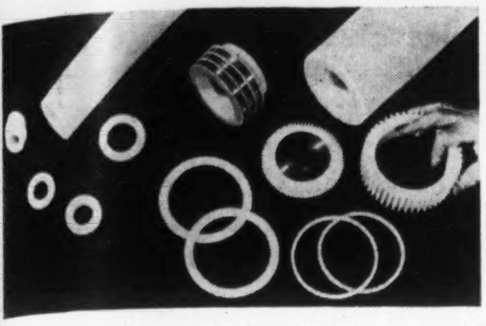
New Materials, Parts, Finishes



Centrifugally Cast Nylon Shapes

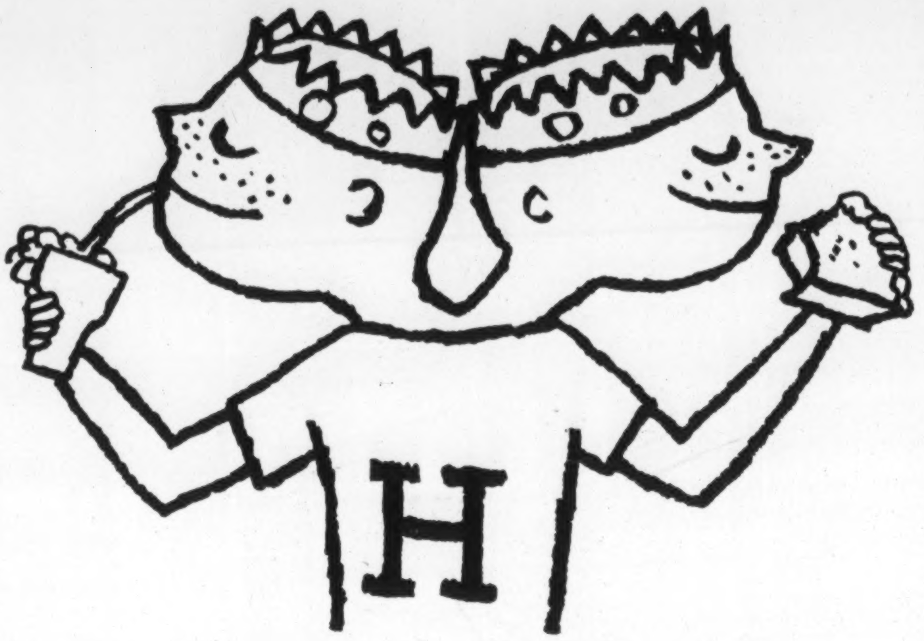
Centrifugally cast, turned and concentrically bored nylon tubular bars in a range of stock similar to that generally available in brass and bronze are being marketed by the *Polymer Corp. of Pennsylvania*, Reading, Pa. Tubing ranges in o.d. from 2 to 10 in. with wall thicknesses of 3/8 through 1 in. Standard lengths are 8 and 13 in.

According to Polymer Corp. use of tubular bars rather than bar stock eliminates many machining and boring operations in the manufacture of large diameter bearings, thrust washers, wheels, gears and seals. The nylon formulation used is said to provide good wear and frictional properties, toughness, heat resistance, chemical resistance and damping characteristics.

Epoxy Adhesive Aids Metal Bonding

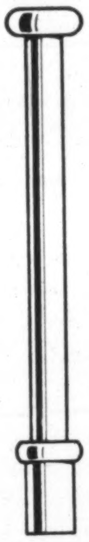
A new one-component epoxy-type metal adhesive has been developed for joining materials such as ceramics and glass to metal as well as metal-to-metal. It is supplied in paste form and the only pressure required is that necessary to hold parts together during a one hour bake at 350 F. It requires no pre-assembly drying or pre-cure and after curing will withstand temperatures up to 500 F, according to the manufacturer, *Carl H. Biggs Co.*, 2255 Barry Ave., Los Angeles 64. The cured bond is inert to acids, alkalies and salt water.

Designated Helix Bonding Agent No. 385, the material has a spe-



OFTEN

TWO HEADS ARE BETTER THAN ONE



Often two heads are the only solution to a part or fastener problem. Take just a moment to look at this pump valve-plunger. It's a tricky job calling for two heads and two different shaft diameters. The big problem here was to produce this valve-plunger in *quantity, inexpensively* and *quickly* . . . and Hassall double-heading did the trick.

Double-heading is only one example of the almost limitless possibilities Hassall cold-heading offers you. If you have a fastener problem just send us samples or specifications for a quotation.

WRITE FOR CATALOG . . . with it we will send our popular decimal equivalent wall chart.
John Hassall, Inc., Box 2174, Westbury, L. I., N. Y.

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SPECIAL NAILS RIVETS SCREWS
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NAILS, RIVETS, SCREWS
AND OTHER COLD-HEADED
FASTENERS AND SPECIALTIES

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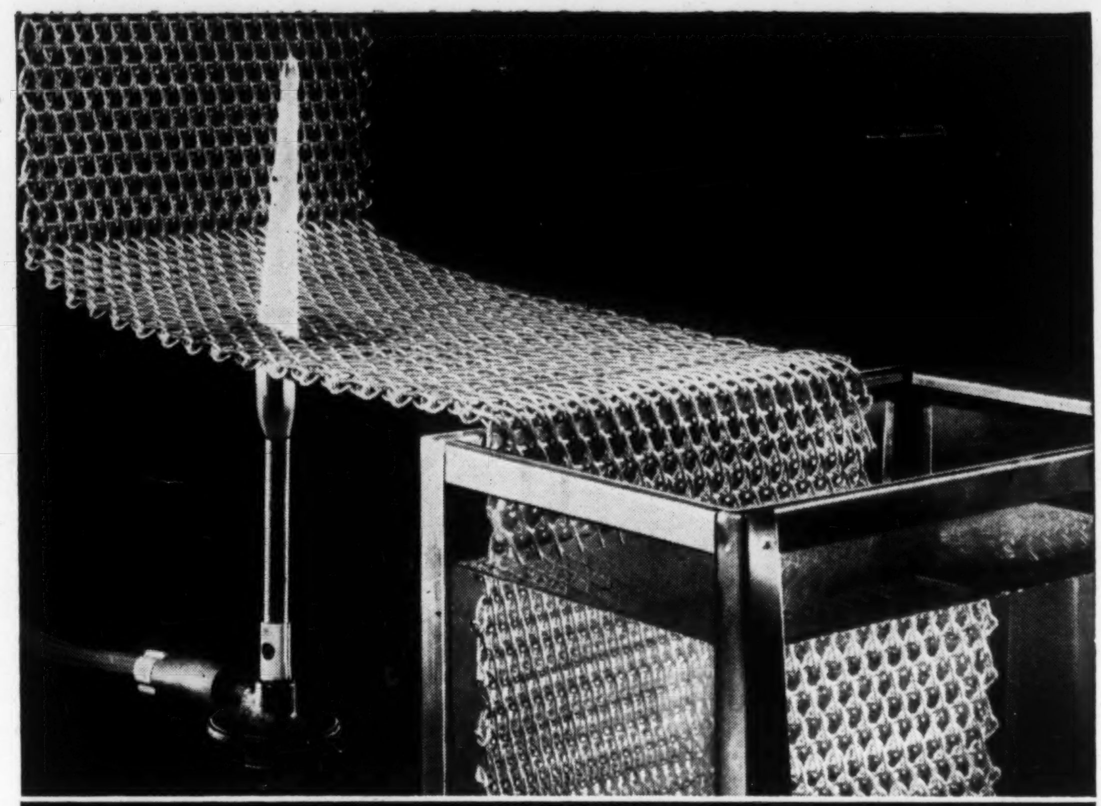

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Cambridge

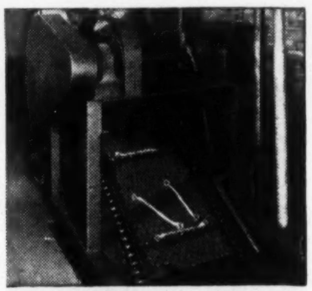
WOVEN WIRE CONVEYOR BELTS

permit continuous heating, quenching, washing

All-metal belt . . . corrosion resistant and impervious to damage at temperatures up to 2100° F . . . withstands most severe conditions of annealing, tempering, brazing, as well as quenching, pickling, washing. Moving belt eliminates batch handling, cuts costs, provides continuous production.

Cambridge Woven Wire Conveyor Belts have no seams, lacers or fasteners to wear more rapidly than the body of the belt . . . no localized weakening. Open mesh construction lets heat and gases circulate freely all around the work, and permits free drainage of process solutions.

No matter how you look at it, CAMBRIDGE Woven Wire Conveyor Belts are invaluable aids to AUTOMATION . . . eliminate profit-stealing batch and hand operations. They are made in any size, mesh or weave, and from any metal or alloy. Special raised edges or cross-mounted flights to hold your product during movement are available.



CONTINUOUS QUENCHING—of small or large parts on a Cambridge belt is faster and cheaper.

Call in your Cambridge Field Engineer to discuss how you can cut heat treating costs by continuous operation. You can rely on his advice. Write direct or look under "BELTING, Mechanical" in your classified phone book.

ASK FOR FREE 130-PAGE REFERENCE MANUAL illustrating and describing woven wire conveyor belts. Gives mesh specifications, design information and metallurgical data.

Cambridge
CONVEYOR BELTS

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

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CAMBRIDGE 9,
MARYLAND

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

For more information, turn to Reader Service Card, Circle No. 319

cific gravity of 1.18, a compressive strength of 18,000 psi and shear strengths of 3500 psi at room temperature, 1800 psi at 180 F and 1500 psi at 250 F. It withstands a temperature range of —60 to 500 F and is black in color.

Light Weight Casting Resin

A new epoxy casting resin is said to combine a wide range of temperature resistance with light weight (specific gravity, 0.90). Developed by *Emerson & Cuming, Inc.*, 869 Washington St., Canton, Mass., Stycast 1090 is said to be useful from —100 to +400 F, to have excellent adhesion to a wide variety of materials and negligible shrinkage during cure. Thermal expansion coefficient is close to that of most metals. According to the company it will prove particularly useful in aircraft applications where weight is a critical factor.

New Tapes Serve Variety of Purposes

A variety of new tapes has recently been marketed by several companies to serve many purposes: 1) black crepe paper masking tape; 2) tape for bag sealing and general packaging; 3) polyvinyl chloride pipe-wrap tape; 4) two dielectric tapes, one designed for splicing, the other of Mylar is designed for general purpose insulation; 5) three general purpose tapes, one of cellophane, one of paper and the third of plastics.

Masking tape

A new masking tape consisting of a semi-glossy, flattened crepe backing with a transparent adhesive has been developed for all-purpose use in plant work by *Permacel Tape Corp.*, New Brunswick, N. J. Designated P 717, the tape is said to be effective over a

For more information, Circle No. 326➤

THE
MACHINE TOOL
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CHICAGO, ILL.
SEPT. 6-17, 1955
INTERNATIONAL AMPHITHEATRE

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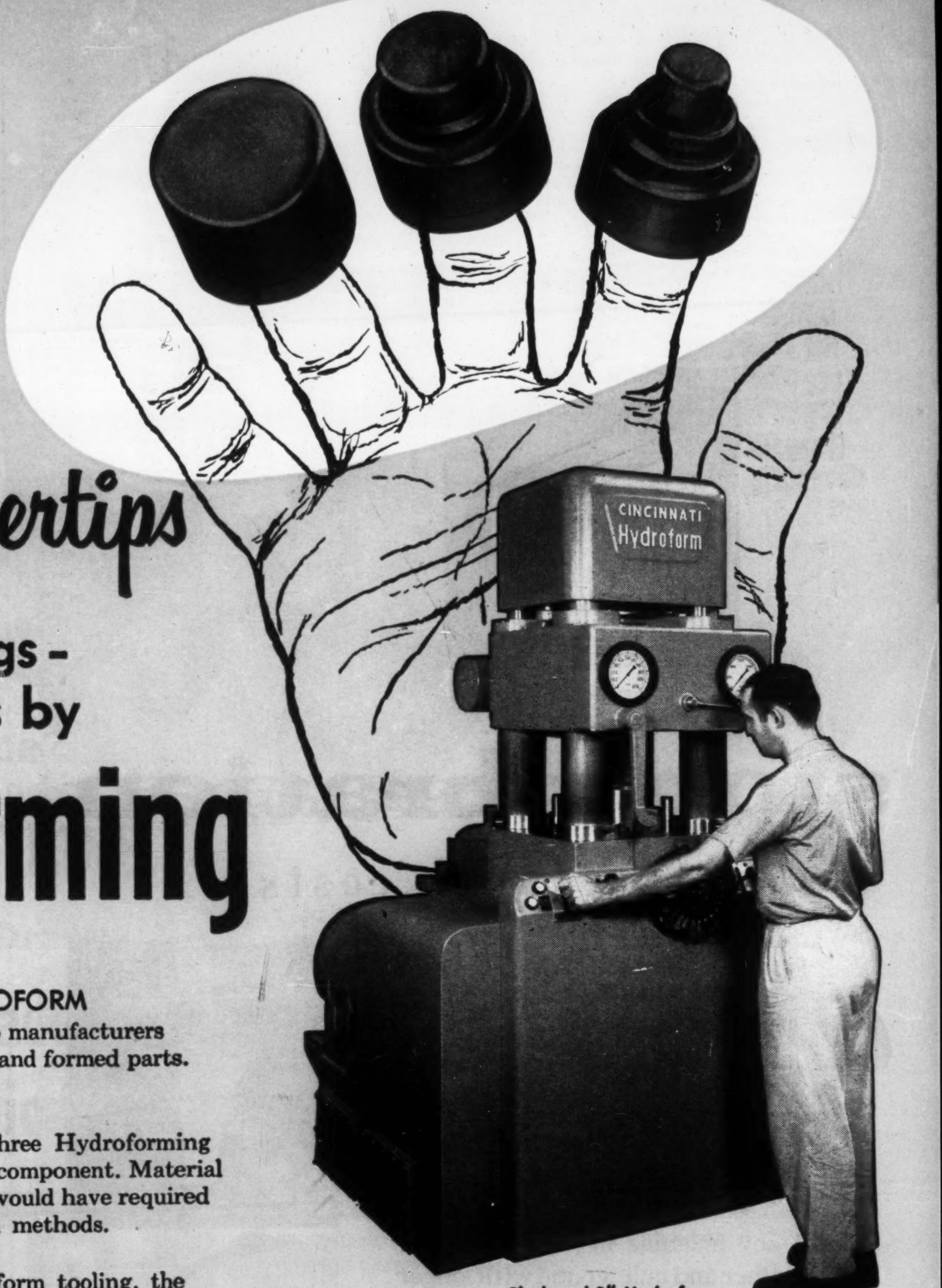


At your fingertips

and at real savings - small drawn parts by

Hydroforming

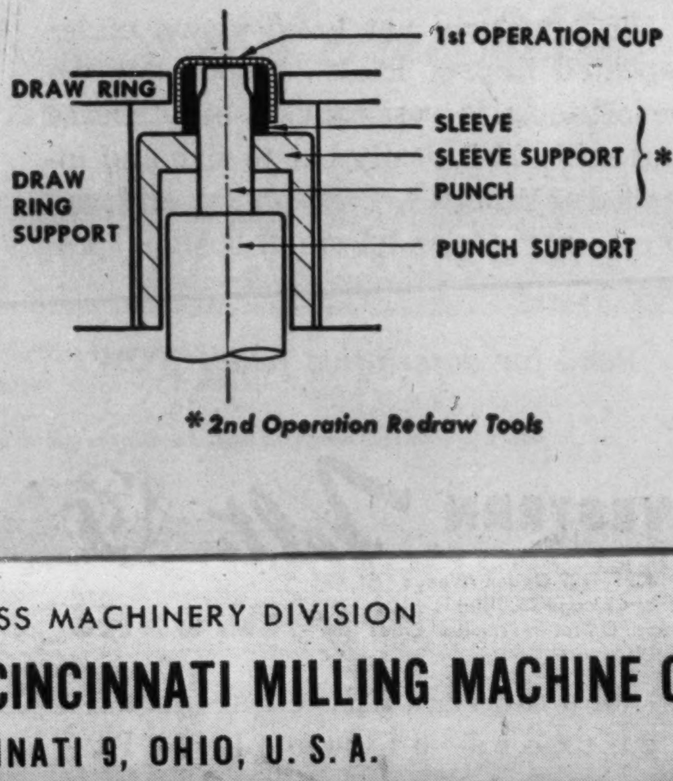
Cincinnati 8" Hydroform

THE NEW CINCINNATI 8" HYDROFORM brings decided time and cost savings to manufacturers required to produce small, deep drawn and formed parts. Illustrated above is a typical example.

The photo shows, in sequence, the three Hydroforming operations to produce an electron tube component. Material is 0.020" O. F. H. C. copper. This part would have required five or six operations by conventional methods.

To illustrate the simplicity of Hydroform tooling, the diagram below, right, shows the redraw tools used in the second operation. The sleeve, sleeve support and punch were made of ordinary steel, turned on a lathe. The 1½" dia. x 1¼" deep 1st operation cup was simply placed on the sleeve and redrawn. Redraw tools for the final operation were similar and equally inexpensive.

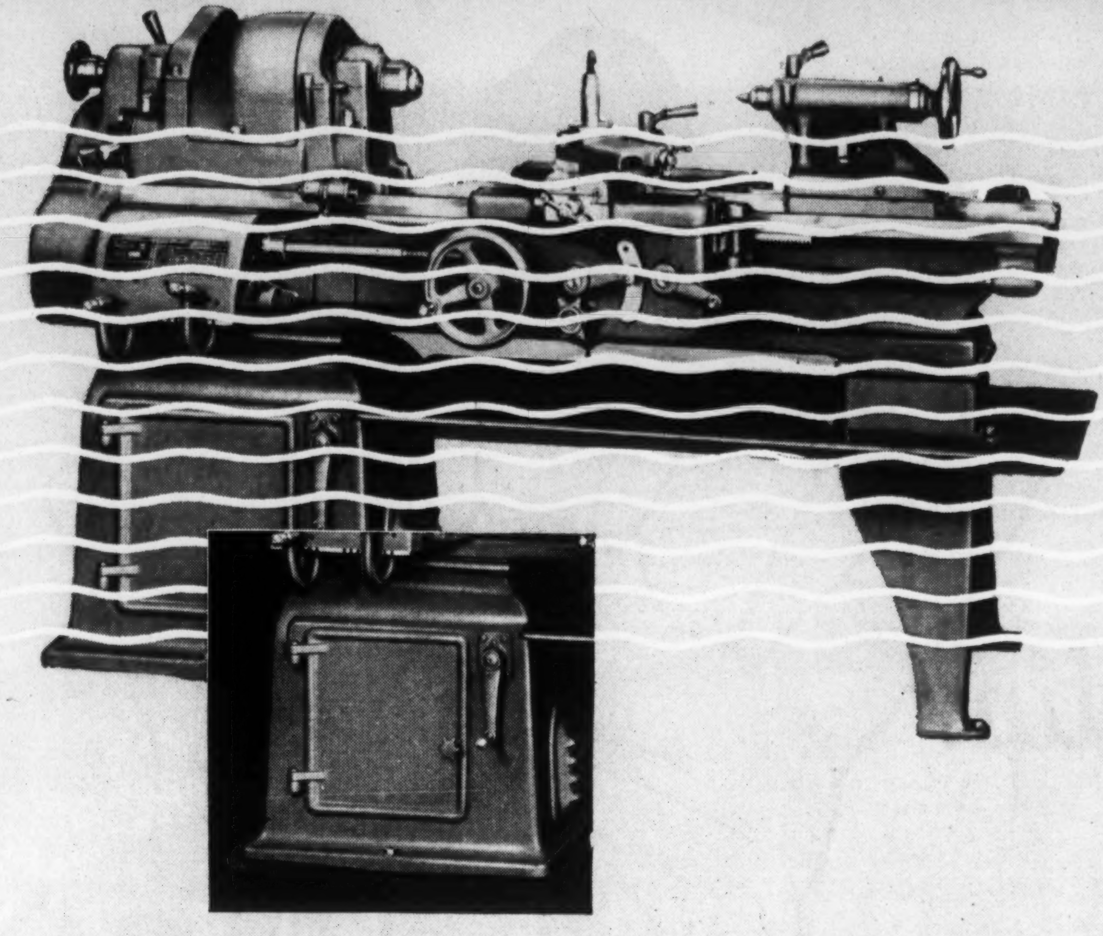
Parts from sheet materials up to ¼" steel, from blanks up to 8" in diameter, can be drawn on the 8" Hydroform. Maximum draw depth is 5". For larger work, Hydroform machines of 12", 19", 23", 26" and 32" capacities are available. Let a Cincinnati Milling field engineer give you detailed information on how you can profitably apply Hydroforming to your work. For a description of the process and specifications of the six machine sizes, write for Bulletin M-1759-3.



*2nd Operation Redraw Tools

Hydroform

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.



stop ~~vibration~~

cut maintenance costs with

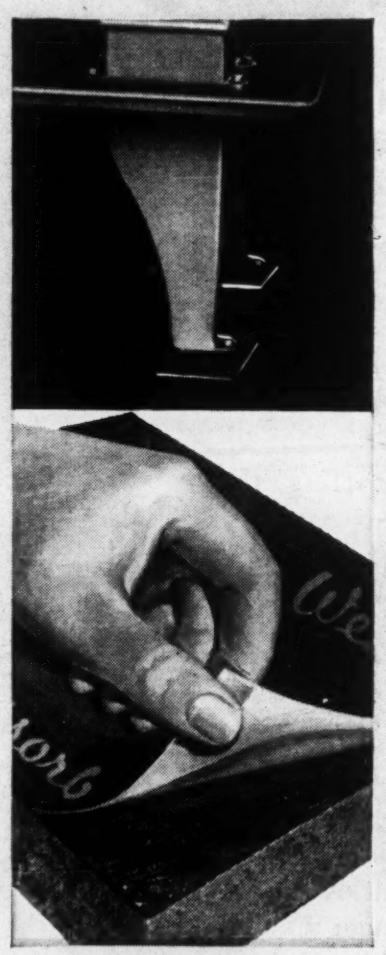
Westsorb®

ADHESIVE-COATED* FELT MOUNTS

Almost any machine in your plant will run smoother and quieter and with longer time between shut-downs if mounted on Vibration-absorbing Westsorb.

Westsorb will not break down under repeated impact loads . . . does not deteriorate . . . is resistant to oils, grease and acids. It is easily cut to size and installed — WITHOUT BOLTS — and can save many times its small cost by preventing future trouble.

Send for descriptive folder NOW!



Pre-applied to both sides. Peel off protective backings and Westsorb is ready for use. Sticks firmly to *any* dry surface — NO BOLTS needed. No down-time waiting for adhesive to set. Operate units immediately.

WESTERN Felt WORKS

4021-4139 Ogden Avenue
Chicago 23, Illinois
Branch Offices in Principal Cities

Manufacturers and cutters of wool felt

Dealers Inquiries Invited

◄ For more information, Circle No. 422

temperature range of 50 to 240 F. The firmness of the adhesive prevents cold flow and according to Permacel, adhesive will not transfer upon removal of the tape from a surface. It is recommended as a bundling tape for combining insulated wires in TV, radio and other household appliance assemblies, as well as for general-purpose masking use.

Packaging tape

A line of pressure-sensitive paper-backed tapes for packaging has been marketed by *Permacel Tape Corp.*, New Brunswick, N. J. The tape is available in 8 different colors and in ½ and ⅜ in. widths. P 727 is printable with analine or oil-based inks or with pencil. The adhesive is rubber-based and stain-resistant.

PVC pipe-wrap tape

A pressure-sensitive polyvinyl chloride pipe-wrap tape said to feature high adhesion and conformability at temperatures ranging down to zero F has been developed by *Minnesota Mining and Manufacturing Co.*, Dept E-584, 900 Fauquier St., St. Paul 6, Minn. In addition to the low temperature flexibility of the tape, the adhesive is said to adhere well at all temperatures and to contain a corrosion inhibitor. Two tapes are available: Scotchrap No. 50, which is 10 mils thick designed for use where maximum conformability is required; and No. 51 which is 20 mils thick designed for straight-run wrapping. The all-weather tapes are expected to find increased use for wrapping above-ground and buried pipes in such applications as pipelines, tank farms, chemical works, gas and water mains and wherever corrosion is a problem. They are available in 100 ft lengths and in widths of 1, 6, 8, and 12 in.

Dielectric tapes

A high voltage splicing tape has been developed for use on ozone-resistant power cables operating at temperatures of 185 F up to

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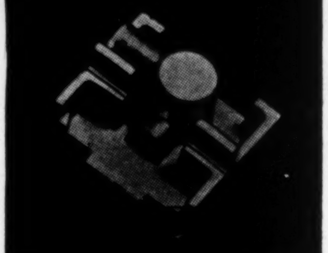

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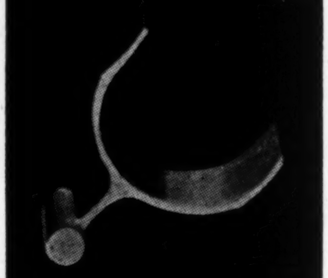

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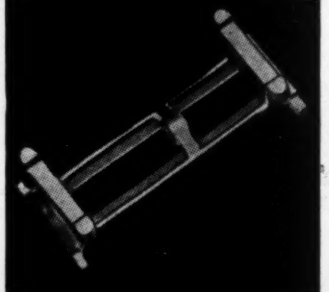

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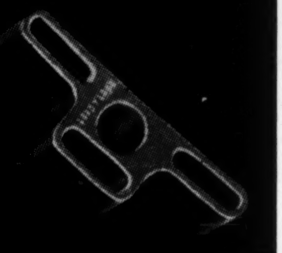
Perfect as instrument alloy. Fully uniform with no internal strain. Can be used for accurate, thin-sectioned castings.



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and including the 15,000 v range. Produced by *Bishop Mfg. Corp.*, 112 Factory St., Cedar Grove, N. J., Bishop No. 30 is said to fuse into a homogeneous, moisture-proof wall which equals or betters the original insulation. It is recommended for use on all cables insulated with ozone-resistant compounds and operating at 2000 v or more. It is said to have high resistance to erosive action of both corona and ozone as well as superior aging properties.

An electrical heat curing tape made of Mylar polyester film has been marketed by *Permacel Tape Corp.*, New Brunswick, N. J. Permacel 253 has good pressure-sensitive characteristics in the uncured state and can be subjected to heat which cures the adhesive and makes it solvent resistant. It consists of 1 mil of Mylar and a rubber-base adhesive. The tape is said to have a tensile strength of 20 lb per in., elongation of 50%, adhesion to steel of 40 oz per in., and a minimum curing cycle of 2 hr at 250 F or 1 hr at 300 F. It has low water vapor permeability and will withstand temperatures up to 300 F. Applications for the tape include banding field and armature coils and holding down lead wires in electric motor and generator manufacture; holding down start and finish wires, securing leads, insulating cores and providing an outside wrap which is resistant to moisture, abrasion and chemicals in transformer and coil manufacturing; and use in class B insulated electronic and electrical components.

General purpose tapes

A cellophane pressure-sensitive tape, guaranteed against breakage has been marketed by *Permacel Tape Corp.*, New Brunswick, N. J. The tape, called Texcel 44 is said to be particularly resistant to extremes of temperature and humidity. If trouble should be encountered because of extremely dry or humid conditions, the tape will be

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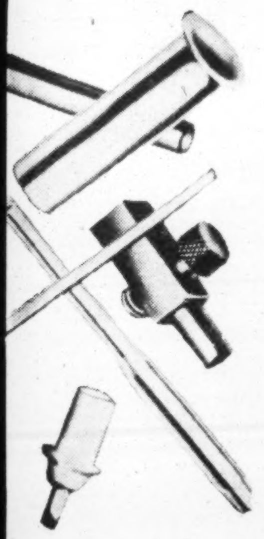

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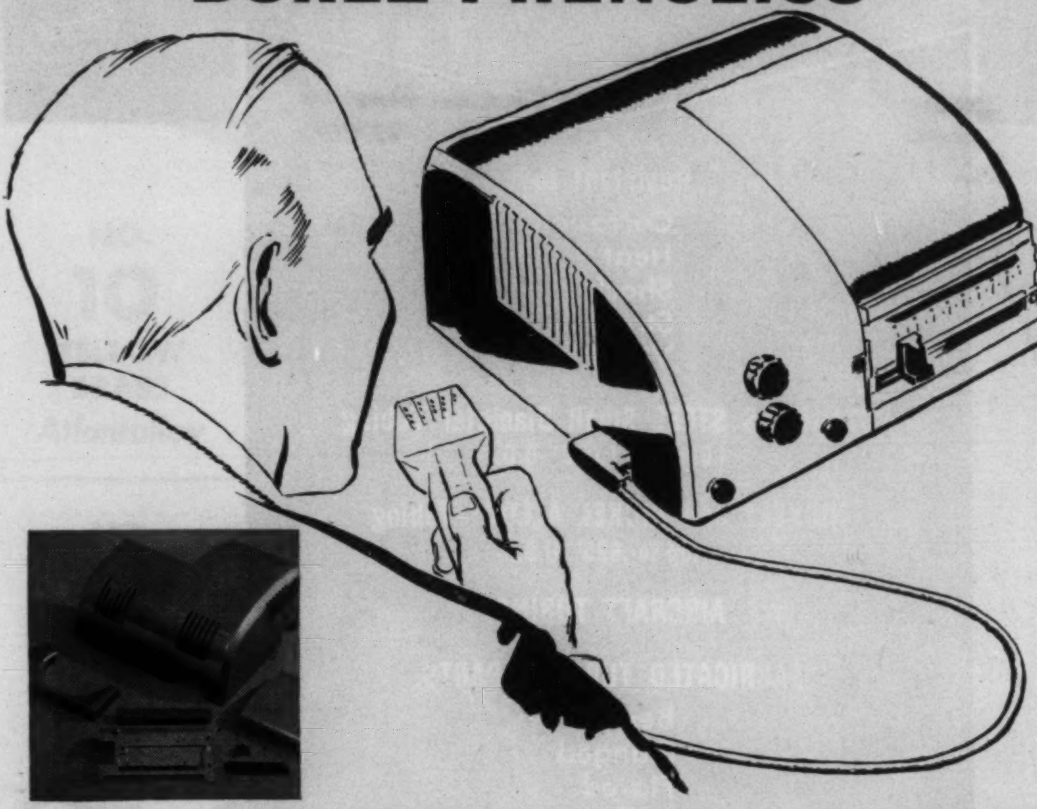

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replaced free of charge. The tapes are said to have good storage life and are available in rolls of 1296 and 2592 in.

Plastics tapes available in 10 different colors, waterproof and washable, have also been marketed by Permacel. All colors are said to have a smooth, glossy appearance and to be flame, stain and fade resistant. They provide optimum opacity, and high adhesion and tensile strength. Designated Texcel 33, the tapes are available in ¾ and 1½ in. widths.

A new adhesive paper tape designed for industrial holding applications which require high strength and adhesion with freedom from adhesive deposit, has been developed by *Behr-Manning Div. of Norton Co.*, Troy, N. Y. Minimum tensile strength of No. 131 Behr-Cat Flatback is 45 lb per in. width and adhesive strength is 65 oz per in. of width with an elongation of 5%. The tape can withstand temperatures up to 250 F. It is available in widths from ¼ in. to 3 in. with greater widths available on order.

Cleaner, Passivator for Stainless Steel

Permapass is an acidic liquid mixture which, in one application at room temperature, removes light weld burns, acid stains, rust and free iron, and cleans, degreases and passivates stainless steel surfaces. It has been marketed by *Concor Chemical Co.*, P.O. Box 846, Hoboken, N.J. It is not intended as a replacement for conventional nitric acid passivation procedures, but is said to provide comparable results in applications where hot nitric acid method is impractical, i.e., large fabricated parts and installations.

Since the material may be applied by brush, dip or spray and rinses easily, it is relatively simple to apply and eliminates the need for large processing tanks. Complete passivation is said to take about 20 min. Though Permapass is

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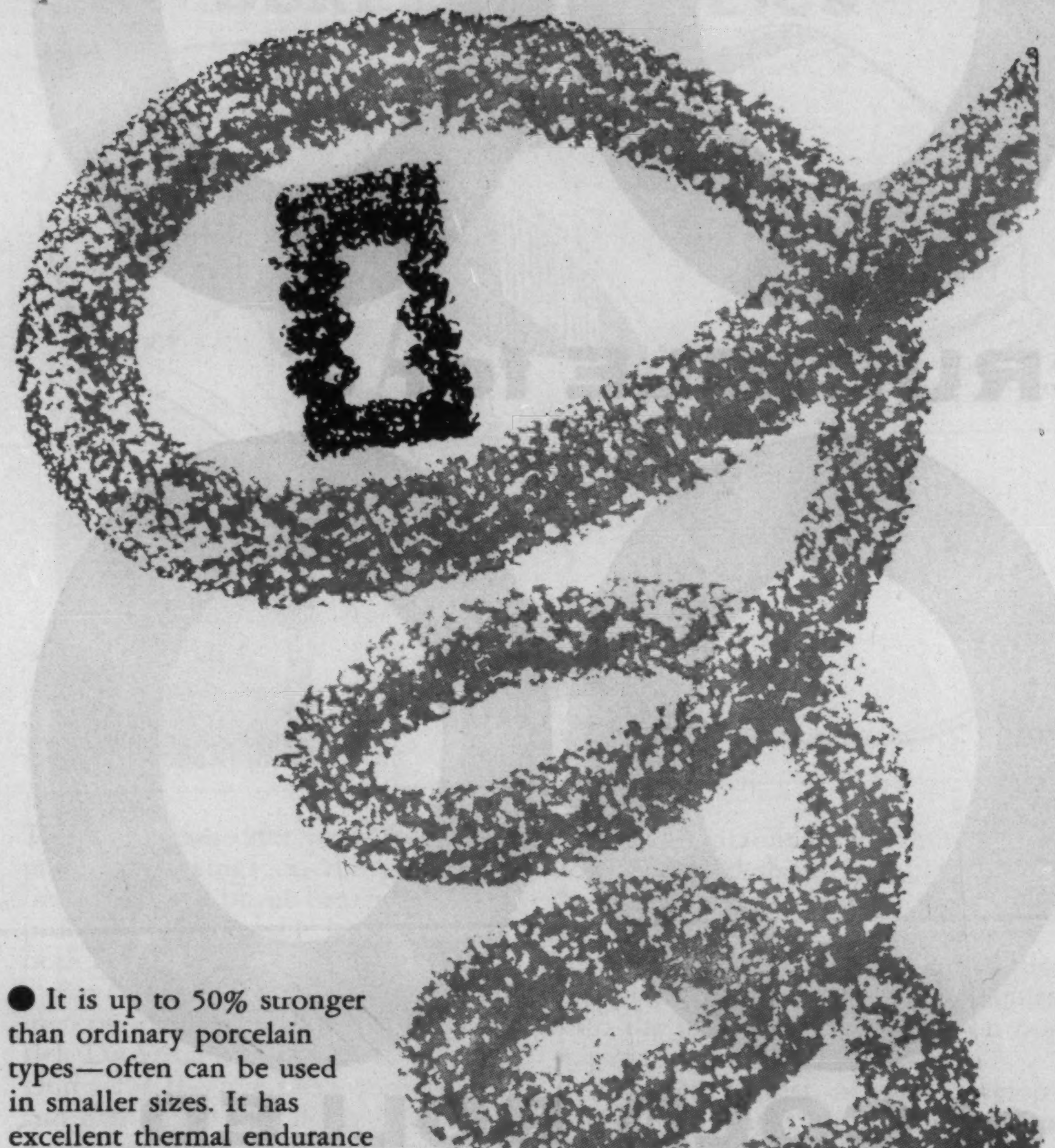

● It is up to 50% stronger than ordinary porcelain types—often can be used in smaller sizes. It has excellent thermal endurance—resists heat shock of soldering in making a ceramic to metal seal. High mechanical strength and maximum resistance to moisture penetration are among other features which include favorable electrical characteristics.

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acidic and should be used with due caution, it is not as hazardous as nitric acid. Concor warns that the material deteriorates after about 1 mo at 60 to 70 F, and builds up pressure in closed containers. It should be stored in a cool place and vented frequently.

Accurate Castings by New Method

Tolerance, finish and sectional thickness limitations of castings produced by a new casting method are said to be comparable to those of conventional investment casting. Developed by Lebanon Steel Foundry, Lebanon, Penn., the process called Ceramicast is said to be fast and economical and makes use of any kind of inexpensive pattern material. It is adaptable to any castable alloy and there is virtually no limit to size of casting, according to Lebanon.

Features of Ceramicast parts include: 1) surface smoothness can be held to about 125 rms; 2) intricate shapes possible; 3) metal sections can be held as thin as 1/16 in.; 4) tolerances in one-half of the mold can be held to 0.003-0.005 in., 0.006-0.010 in. across parting lines; 5) reductions in machining time and cost; 6) lower casting cost; 7) short lead time; and 8) adaptability to almost any casting size or alloy.

The process

Mold material consists of ethyl orthosilicate and silimanite. The mixed material is poured on the pattern. After it sets, it is stripped from the pattern and set aflame to burn off most of the alcohol. Molds are then placed in a 1000 F furnace for 30 min per in. of thickness to cure out the organic material. The result is a gas-free ceramic mold.

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- *Plastics pipe*
- *Vacuum metals*
- *Diffusion coatings in Russia*
- *Friction materials*
- *Charpy test reproducibility*

Creep in Plastics Pipe

Plastics materials exhibit creep behavior similar to metals. This behavior must be understood and accounted for by the designer in selecting the proper material to meet his product's service conditions. Increasing use of plastics pipe has been accompanied by an increasing need for more accurate data on this design factor. Preliminary results of investigations to determine 1) creep of cellulose actetate butyrate plastics pipe under internal pressure and 2) creep characteristics of rigid polyvinyl chloride were reported last October at the Dallas meeting of the Unit Committee T-1J of the National Association of Corrosion Engineers.

Butyrate pipe creep

L.W.A. Meyer and R.J. Scogin reported on preliminary results of long-range investigations being carried out by Tennessee Eastman Co. to determine the highest safe hoop stress which any given size of extruded Tenite Butyrate pipe will withstand at various temperatures. Hoop stress is used in calculating safe working pressure for a given size of pipe or for determining wall thickness necessary to withstand a given pressure. The practical application of hoop stress values can be quickly seen by a sample calculation, using the hoop stress formula:

$S = \frac{PD}{2T}$ where:

S = Hoop stress, psi

P = Internal pressure (e.g., 90 psi)

$S = \frac{90 \times 2.242}{2 \times 0.119}$ where:

D = Outside dia (e.g., 2.242 in.)

S = 850 psi where:

T = Wall thickness (e.g., 0.119 in.)

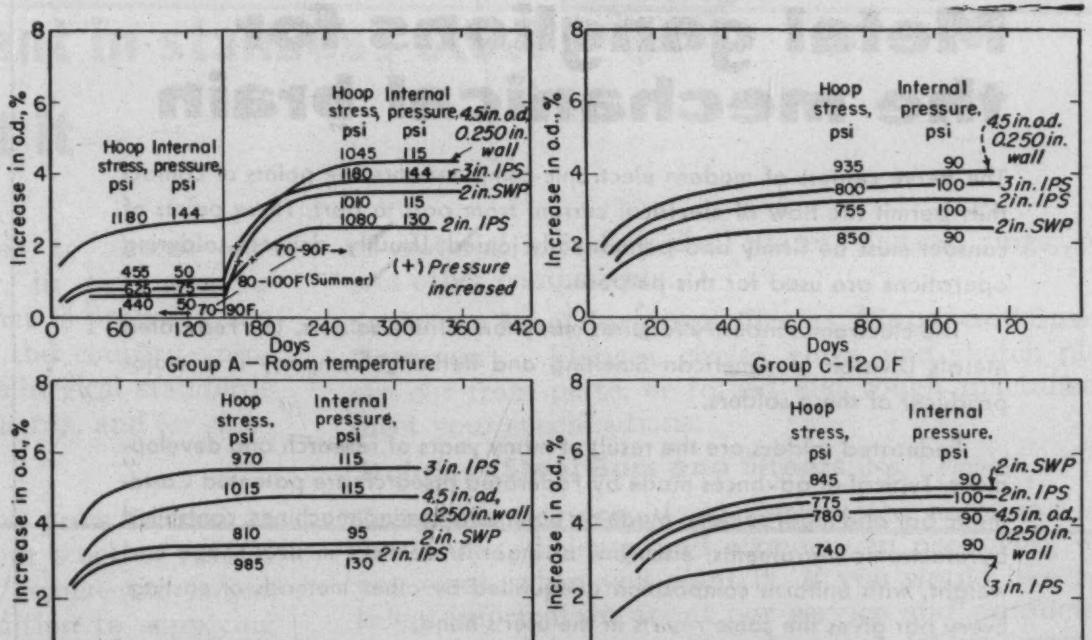
Four different sizes of pipe have been tested, ranging in o.d. from 2.25 in. with 0.125 in. wall to 4.5 in. with 0.250 wall. Each of the four sizes of pipe was tested wet in two different formulas both at room temperature and at 120 F and at five different internal pressures. The four accompanying graphs summarize creep data gained for the pipe and test conditions.

The authors suggest that consideration be given to safe hoop stress values as shown in the accompanying graphs. They represent only about 15-20% of short time tensile strength, roughly confirming previous assumptions. Previous estimated safe working pressures for this type of pipe have been calculated on an arbitrarily chosen basis of 20% of tensile strength. The authors caution, however, that the tests described were run at a constant pressure and were not subjected to impact loading caused by water hammer or by external force.

Creep in unplasticized PVC

G. F. Malone of B. F. Goodrich Chemical Co. reported on work done by M. L. Dannis to determine effect of temperature on structural behavior of Geon rigid vinyl resins, both of the normal impact types and the high impact types. The materials behave in a fashion similar to metals in that strength decreases with increase in temperature. Creep properties are a function of temperature in that slightly increasing temperature greatly increases creep rate.

Creep properties of rigid vinyl



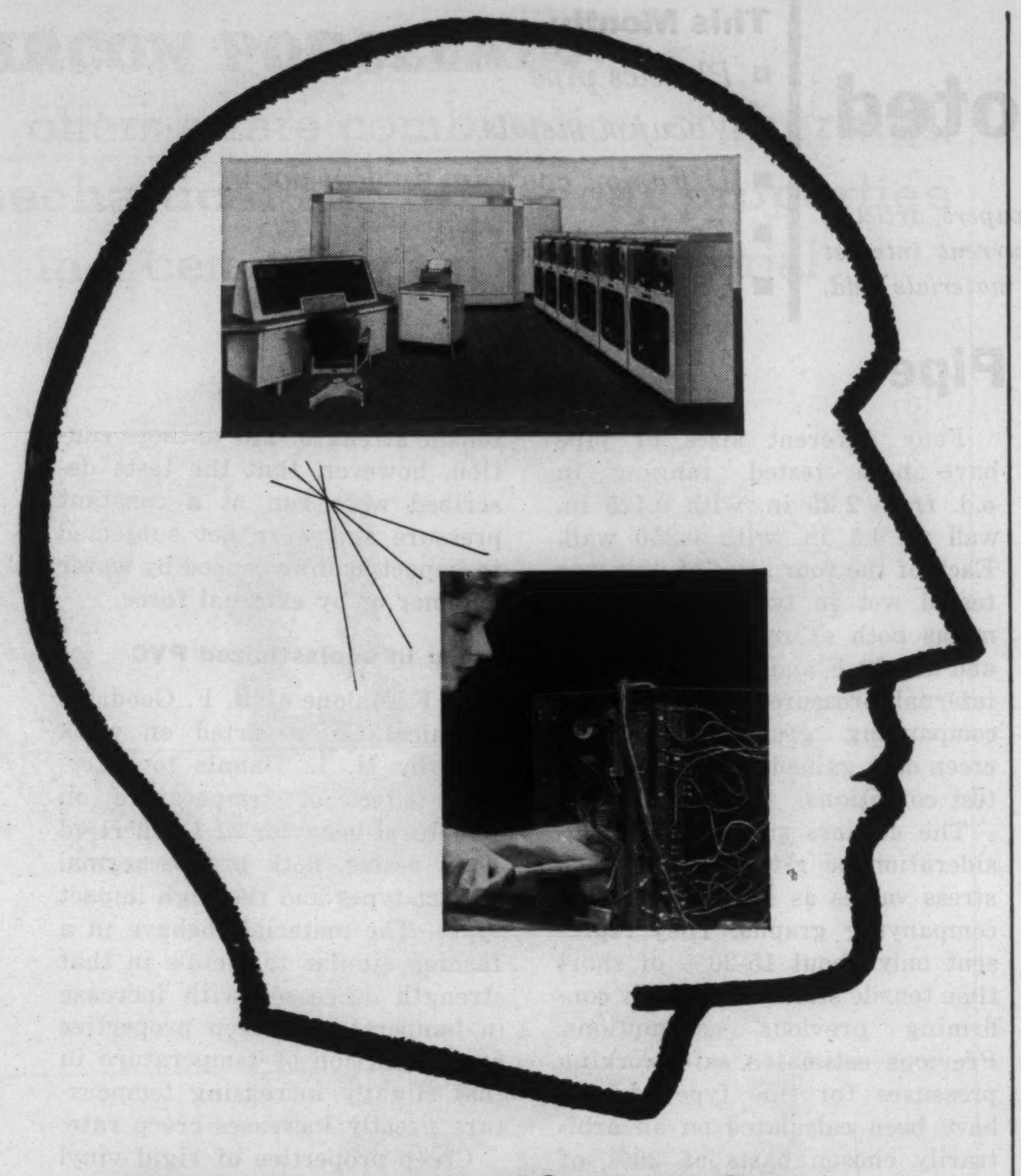
Summary of creep data for two Tenite Butyrate pipe formulations (wet) at room temperature and at 120 F, showing safe hoop stress ranges for each.

Group A—Formula 435E-22300, at room temperature. Safe hoop stress range: 1010-1180 psi.

Group B—Formula 265E-20337, at room temperature. Safe hoop stress range: 810-1015 psi.

Group C—Formula 475E-22300, at 120 F. Safe hoop stress range: 755-935 psi.

Group D—Formula 265E-20337, at 120 F. Safe hoop stress range: 740-845 psi.



Metal ganglions for the mechanical brain

The nerve centers of modern electronic computers are the points of contact that permit the flow of electrical current from part to part. These points of contact must be firmly and permanently joined. Usually, delicate soldering operations are used for this purpose.

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Federated solders are the result of many years of research and development. Typical of advances made by Federated research are patented Castomatic bar and ingot solders. Made on automatic casting machines, controlled by electronic instruments, each bar or ingot is identical in size, shape and weight, with uniform composition unequalled by other methods of casting. Every bar gives the same results in the user's hand.

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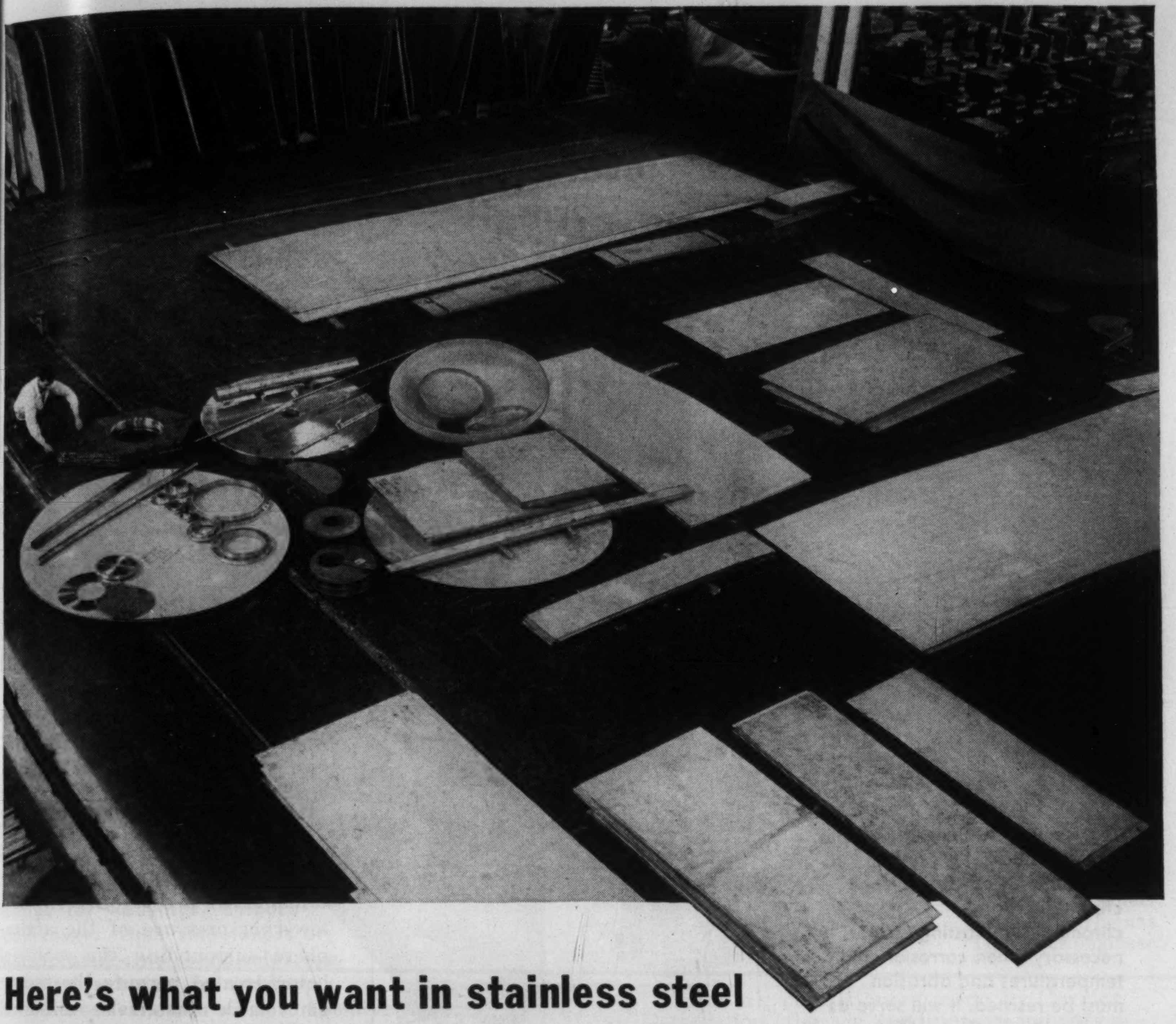
seem to fall into two general classes of behavior. At relatively low stresses, deflection and rate of creep are directly proportional to applied stress. Above some stress limit, varying between 2200 and 3000 psi, deflection and rate of creep increase much faster than stress. Therefore, a minimum safety factor of 5 to 1 or 20% of ultimate tensile strength should be chosen.

To determine deformation in a part due to long-term creep and elastic stretch, Dannis has developed graphs where elapsed time is plotted against what he calls the time dependent modulus, E(t). $E(t)=S_o/S(t)$, where S_o=initial stress and $S(t)$=strain at time, t. By plotting test values for various stresses, curves have been developed for polyvinyl chloride. These curves can be used to pick modulus values for the material which in turn can be inserted in formulas to determine the amount of creep and elastic stretch to be expected after a stated length of time. For example, to determine increase in length of a piece of plastics pipe suspended vertically, the formula can be used: $\Delta L=L \times S_{av}/E(t)$, where L = length of pipe and S_{av} = average stress. If these two latter values are known, the value for the time dependent modulus E(t) can be read from the graph for whatever length of time desired. By substituting this value in the formula, amount of creep and elastic stretch to be encountered can be rather closely determined.

Latest Advances in Vacuum Metallurgy

Recent research has revealed that substantial improvements in mechanical properties of certain metals and alloys result from vacuum processing. Furthermore, many promising alloys could not have been developed without this tool. A large part of the Symposium on Vacuum Metallurgy held



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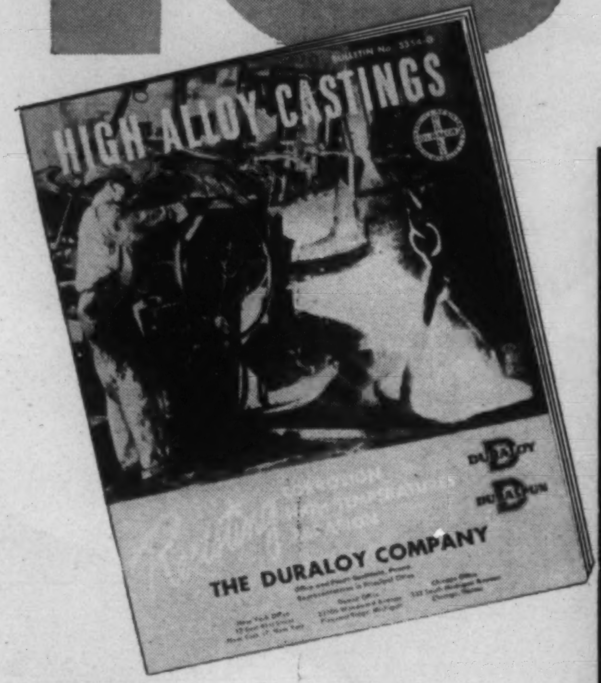
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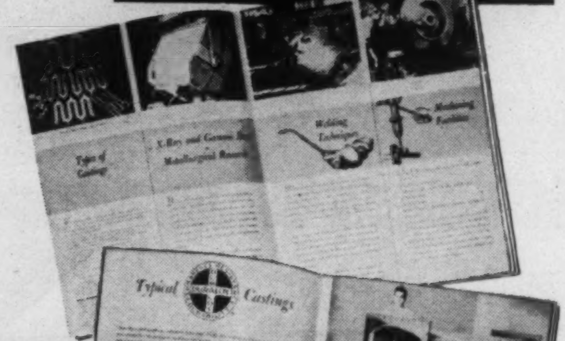
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High Temperature Strengths for High Alloy Castings
CASTINGS
Alloys to Meet High Temperature Conditions

This is our New General Bulletin—3354G. It's full of information and data on the chrome-iron and chrome-nickel castings so necessary when corrosion, high temperatures and abrasion must be resisted. It will serve as a general selection guide for those specifying or using such castings.

The bulletin also reviews briefly our experience in both static and centrifugal castings, an experience going back to the pioneering days of 1922 and 1933 respectively. It also tells about our facilities for furnishing castings to any desired analysis, welding, X-ray and gamma ray testing, metallurgical and foundry control.

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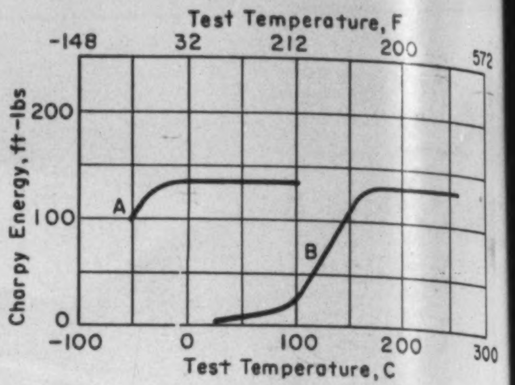
Contents Noted



Charpy transition curves for vacuum-melted 27% chromium alloy with a 1650 F quench to a hardness of Ra 43 (curve A); and for air-melted type 446 stainless steel after a 1650 quench to Ra 50 (curve B).

by the Electrochemical Society in October last year consisted of papers describing results of the latest investigations by various workers in the field.

Advantages of vacuum processing derive from either or both of two salient features of a vacuum. As a protective feature, a good vacuum provides a contaminant-free atmosphere superior to inert gases of the highest purity obtainable. As a corrective feature, lowering pressure of the atmosphere surrounding the material being treated permits the escape of volatile materials, dissolved gases, or gaseous products of reactions between contaminants. Escape pressures of some of these gases are so low that the treating chamber must be evacuated to a millionth of atmospheric pressure to make the treatment effective. Of course, the rate of volatilization of the metal is also increased under these conditions. Thus, the applicability of vacuum processing is generally limited to the nonvolatile metals, with the exception of reclaiming alloy components by vacuum distillation. Progress at the Bureau of Mines, in this field was discussed in a paper by M. J. Spendlove.

Corrective features

The protective feature of

Papers above were abstracted by Dr. J. M. Blocher, Jr., Battelle Memorial Inst. who organized and acted as chairman of the Vacuum Metallurgy Symposium. The complete papers are now available in bound volume. See "Books" department, p. 204.

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Manufacturers of power tools and equipment, and of many home and office appliances, have discovered the advantages obtained by using the new lightweight alloys for housings, shrouds and covers. Their smoothness of finish provides merchandisable, eye-pleasing, exteriors for products . . . establishes them in a more competitive position in the retail market. Of great importance too: they provide for the manufacturer, mounting bosses, lugs, and core holes, and virtually eliminate machining, finishing and assembling time. Further advantages are obtained by the use of magnesium and aluminum die castings in the definite reduction of shipping weights. For any type of "Cover-Up", or for any other job where these lightweight metals can be used, LITEMETAL DICAST can probably solve your problem.

Let's Talk It Over . . .

LITEMETAL DICAST, INC., is an organization of specialists—men thoroughly experienced in the casting and machining of magnesium and aluminum alloys. Our equipment includes big machines for big jobs—little machines for little jobs . . . the right sizes and types of the most modern die casting equipment for producing parts from the size of a button to large structural parts. Complete facilities for secondary operations are also available.

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Quick action on inquiries.

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Carrier uses weather-seals by Tyer

"We want one that will last . . ", Howard Tyler, Carrier design engineer, tells A. H. Thomas, Tyer sales engineer.

Room air conditioners made by Carrier Corporation, the air conditioning industry's pioneer and leading firm, are engineered for quality performance and permanent, all-weather installation.

The company set up rigid specifications for a one-piece, completely weather-tight seal—and called in Tyer, specialists in rubber since 1856.

Engineers of the two firms developed an all-molded gasket with special suction properties. Water propelled from a fire hose at 70 pounds pressure will break through the glass before seeping under the seal. Corners of the gasket will withstand tension in excess of 100 pounds.

If *you* have a problem involving rubber, call in a Tyer Sales Engineer. Write Dept. 93 for our "Molded and Extruded" catalog.

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The Unusual in Rubber Since 1856

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A Good Fisherman Doesn't Trust to Luck

Alodized aluminum canoe designed and built by Metal Boat Company Division of Grumman Aircraft Engineering Corporation, Marathon, N. Y.

Grumman

Successful angling is the result of studying feeding habits, selecting the proper lure and the right equipment. To catch bass, and other game fish requires a different technique for each species. The good fisherman doesn't trust to luck.

Similarly, there's no substitute for "Know-How" and that's particularly true in adapting metal treating chemicals to established production. It can't be gotten out of books. through black magic or out of a crystal ball. Only years of active contact, with actual manufacturing procedures, can be depended upon for satisfactory solutions of the metal protecting problems constantly confronting manufacturers.

ACP offers ideal products for removing and preventing rust on metal, chemicals to bond paint to steel, zinc, and aluminum, and pickling acid inhibitors. In addition, ACP furnishes a free service of an organization of technical experts with over 40 years' experience in solving metal preservation problems for the largest as well as the smallest operation.

Rely on service backed by experience. You are obligated in no way by consulting our technical staff.

Write or call for further information on ACP chemicals for metal protection.

AMERICAN CHEMICAL PAINT COMPANY
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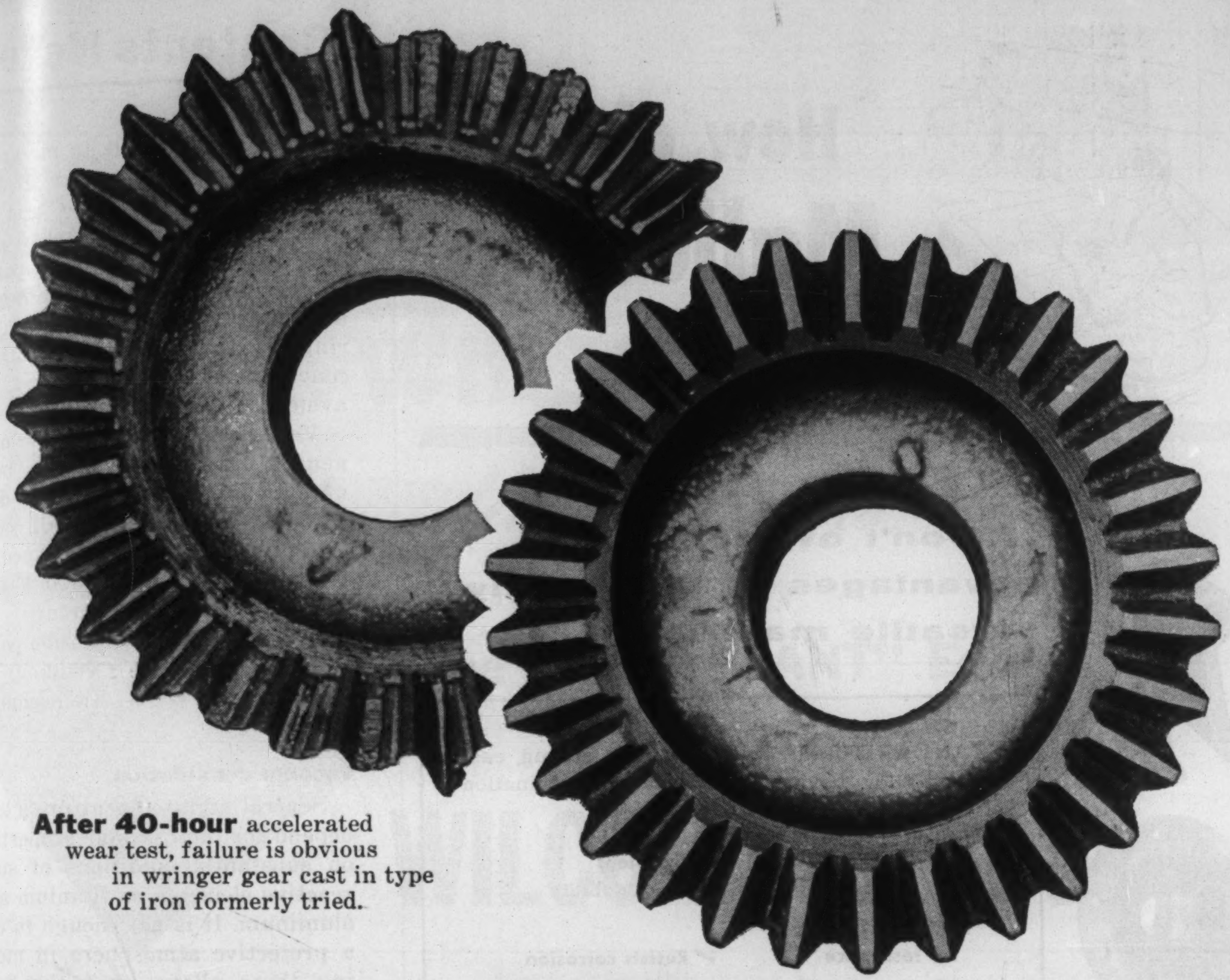
vacuum is finding increasing use in the metallurgy of titanium and zirconium, where pickup of even small quantities of oxygen and nitrogen must be meticulously avoided. However, according to R. L. Hoff and A. M. Bounds of Superior Tube Company, the corrective feature may be equally useful. Recently, the deleterious effect of hydrogen on titanium-base alloys has been brought forcibly to the attention of the industry. It was suddenly realized that large stocks of titanium scheduled for use in aircraft would be worthless until the hydrogen could be removed. Vacuum heat-treating was the answer. For example chromium-iron-titanium clevis forgings failed in minutes at 100,000 to 120,000 psi in room-temperature stress-rupture tests of notched-bar specimens. In comparison, the vacuum-annealed (5 hr at 1250 F) portions of the same specimens withstood 29 to 73 hr at 160,000 psi. Although ordinary tensile tests frequently failed to show the effects of hydrogen on titanium alloys, testing at extremely slow rates of strain gave a reliable indication of hydrogen embrittlement. Thus, the vacuum-annealed sections of these forgings (0.003% hydrogen) broke at about 50% reduction in area, whereas the initial forgings (0.03% hydrogen) failed at 8 to 10%. Quantitative data on rate of removal of embrittling hydrogen from titanium-base alloys were presented by C. B. Griffith and M. W. Mallett of Battelle Memorial Institute.

Age hardening alloys

Beneficial results of vacuum heat treatment are by no means limited to titanium alloys. Hoff and Bounds observed that preservation of full hardenability of thin sections of age-hardening alloys is a problem owing to reaction of the hardening agent with gaseous impurities in the "protective" atmosphere. The reaction can be avoided by carrying out solution- and precipitation-hardening treatments in vacuum. The



After 40-hour accelerated wear test, failure is obvious in wringer gear cast in type of iron formerly tried.

After 256 hours of identical testing, this Ductile Cast Iron gear shows distinctly superior resistance to wear.

Over 500,000 gears prove you can minimize rejects with Ductile Cast Iron

USERS AND PRODUCERS ALIKE gain basic advantages from Ductile Cast Iron.

Here's a typical example, a wringer gear cast in Ductile Iron for washing machines made by The Maytag Company of Newton, Iowa. More than 500,000 such gears now in service attest to two facts: satisfactory response to fabrication, and satisfactory performance for users.

Wringer gears must defeat wear to extend gear life. Test and performance records show how fully Ductile Iron gears meet this need.

But despite high wear-resistance, Ductile Iron is machinable. Indications of improved tool life and finish add to the fabricator's satisfaction with this versatile iron.

In the foundry . . . rejections have been almost zero.

"Castability" of Ductile Iron spells volume output in St. Paul Foundry & Manufacturing Company, St. Paul, Minn., and in Jamestown Malleable Iron Company, Jamestown, N. Y., producers of wringer gear castings for Maytag home washing machines.

Try Ductile Cast Iron. Learn first-hand, how it outperforms other materials under tests and in service. Write now for a copy of the new booklet entitled, "DUCTILE IRON, THE CAST IRON THAT CAN BE BENT."

It's yours for the asking. We'll also send you the latest list of authorized foundries now producing Ductile Cast Iron under patent licenses. Write to INCO now.

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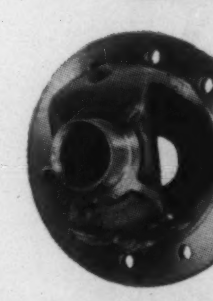

STANDARD malleable iron is a strong cast ferrous alloy having a remarkable combination of properties:

- ✓ Toughness and ductility
- ✓ Excellent machinability
- ✓ High impact resistance
- ✓ Resists corrosion

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- ✓ Exceptional bearing properties
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- ✓ Can be selectively hardened

It's easy to design for simplicity and good appearance in malleable iron—helps you cut costs on current production. Consult your nearest malleable foundry or write to the Malleable Founders' Society for further information.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 472

Contents Noted

method is applicable to materials such as beryllium-copper, K Monel, Inconel X, Ni-Span C and the Elinvar alloys (42 nickel, 5 carbon, 2.5% titanium). They pointed out further that surface deboronization of boron steels occurring on heat treatment in air or conventional atmospheres may be avoided by the use of vacuum.

Vacuum melting to remove oxygen as a volatile oxide has been used to greatly increase the ductility of molybdenum. This same effect is obtained in the vacuum treatment (6 hrs at 3400 F and $<5\times10^{-5}$ mm of mercury) of molybdenum electronic tube parts according to F. C. Todd, J. E. Drennan, and W. W. Kleinschmidt of Battelle.

Vacuum deoxidation

Several high-temperature alloys depend for their unique properties on substantial additions of such reactive elements as titanium and aluminum. It is not enough to use a protective atmosphere in melting these alloys since the base materials themselves are sources of oxygen and nitrogen. Hence, the need for a deoxidizing step in the vacuum-melting process. Recent work at G-E on vacuum deoxidation was described in papers by R. L. Hadley and L. M. Bianchi. Deoxidation of vacuum-melted M-252 (18-20 chromium, 9-11 cobalt, 9-11 molybdenum, 2.25-2.75 titanium, 0.75-1.25 aluminum, 0.10-0.20% carbon, balance nickel) with several deoxidants such as hydrogen, manganese, calcium, aluminum, and cerium, produced material which would be considered excellent from an upsetting standpoint.

Hadley and Bianchi observed that deoxidation by an impinging stream of dry hydrogen on a molten metal surface is capable of reducing the oxygen content of iron, nickel, and cobalt to below 0.005% at 2860 F under conditions applicable to large-scale vacuum melting.

In addition to being ideally constituted for the removal of gases, vacuum melting equipment is also useful in adding controlled

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Announcement

The H. A. WILSON Company

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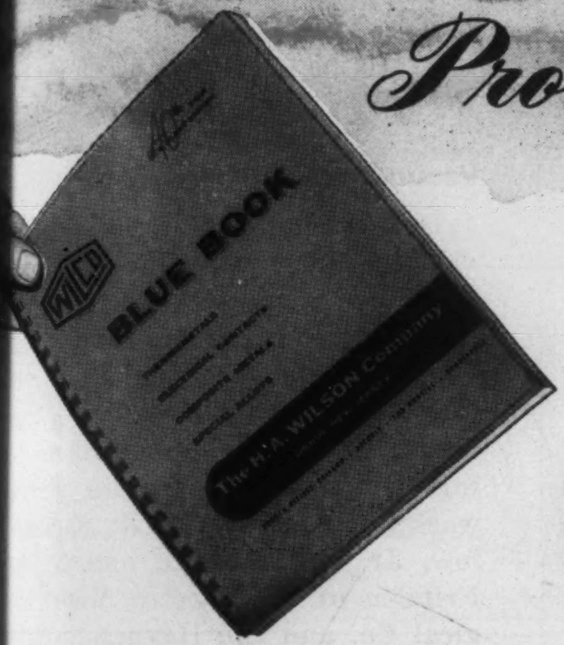

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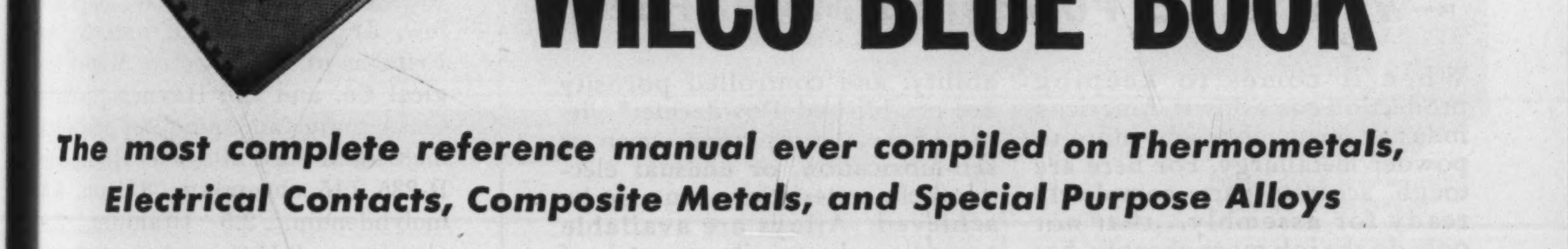

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Contents Noted

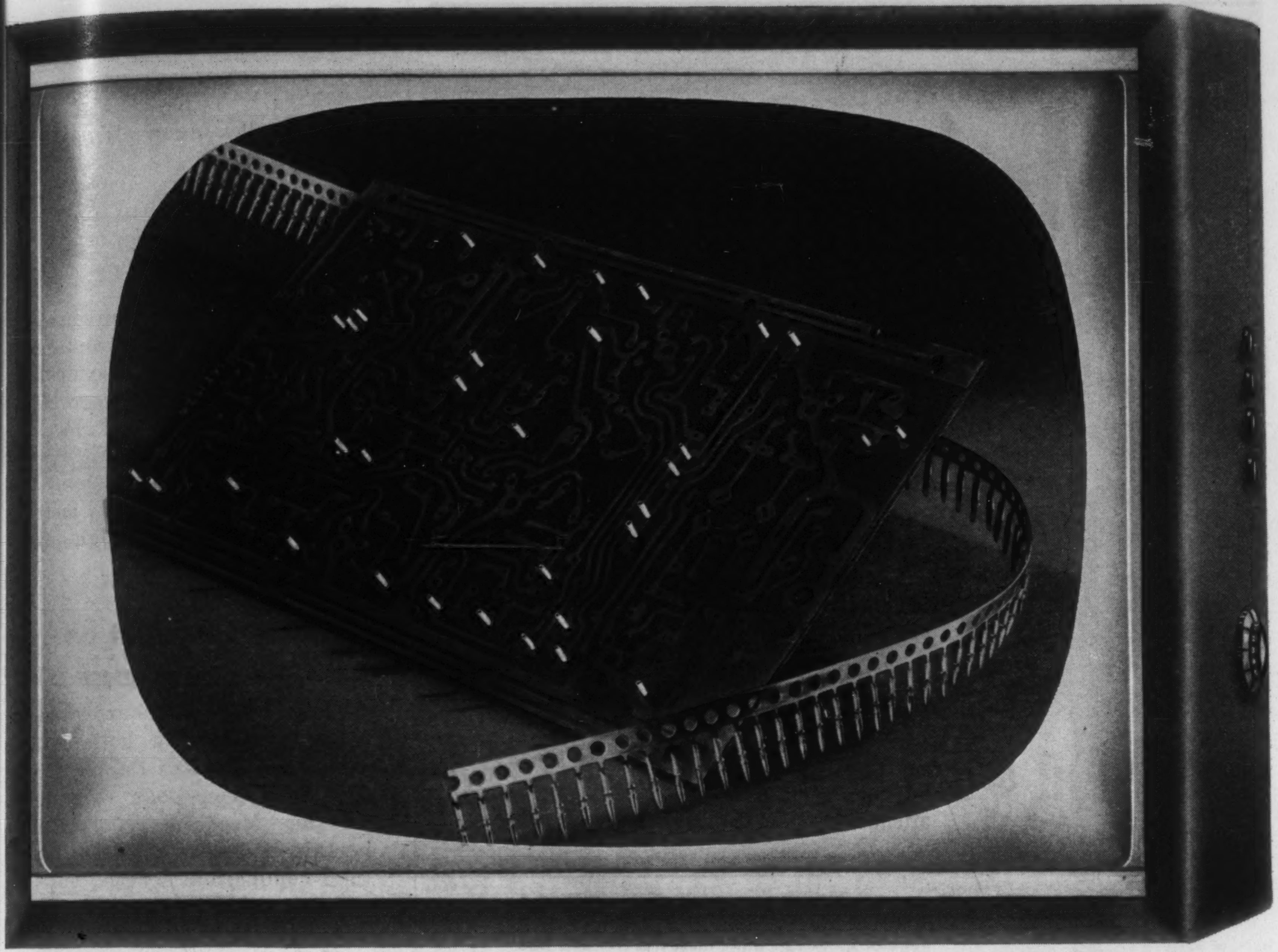
amounts of gaseous alloying agents. Beneficial results of nitrogen additions to austenitic steels was cited as an example by E. R. Morgan and D. N. Frey of the Ford Motor Co. These authors also see a great commercial promise in iron-14% aluminum alloys which can be advantageously melted and deoxidized in high-vacuum equipment. The phenomenal oxidation resistance of these alloys is shown in an accompanying illustration.

Vacuum melted alloys

Improved impact properties of vacuum-melted iron-chromium alloys was discussed in a paper presented by J. L. Ham and F. L. Carr of the National Research Corp. A graphic comparison of the results of vacuum versus air melting as applied to certain alloys was presented by H. R. Spendelow, Jr., I. S. Servi, and G. A. Fritzlen of the Electro Metallurgical Co. and the Haynes Stellite Co. A major advantage of vacuum melting of such alloys as Hastelloy R-235 (15 chromium, 8 iron, 5.5 molybdenum, 2.5 titanium, 2.0 aluminum, 0.15% carbon, balance nickel) is the elimination of undesirable inclusions. These inclusions, consisting mainly of mixed oxides and nitrides, segregate in clusters which form harmful stringers on rolling. Cross sections of as-cast ingots, reveal the effectiveness of vacuum melting in decreasing the amount of inclusions and increasing their dispersion. In general, an improved forgeability was observed. The forging temperature range could be effectively increased for vacuum-melted materials while avoiding hot shortness.

Ductility as measured by stress-rupture tests at 1500 F was markedly increased by vacuum melting. Elongation of most samples of the air-melted alloy was in the range of 0 to 4%, while values for vacuum-melted samples ranged predominantly from 7 to 15%.

The increased control over certain alloy additions made possible by vacuum melting is illustrated



Printed circuit panel courtesy of Admiral Corporation

Brass Snap-in Terminals— key to automatic circuit wiring

Bridgeport High I.Q. Brass permits automatic, high-speed insertion of miniature terminals into printed circuit panels.

Malco Tool and Manufacturing Company of Chicago designed and manufactured these ingenious printed circuit components and the fully automated machines for inserting them into printed circuit panels. To make these precision components for the television, radio and electronic industries, Malco uses Bridgeport's High I.Q. Brass Alloy No. 37. One of the High Inner Qualities of this alloy is its controlled temper—exactly what is needed to meet the critical tension tolerances for this precision machine assembly.

The use of this alloy by Malco is another example of how Bridgeport's High I.Q. alloys are helping to improve products and lower manufacturing costs in a wide variety of industries. To find out how Bridgeport alloys can help in your particular application, call the Bridgeport office near you. They'll give you complete information and the help of Bridgeport's Technical Service on your metals and methods.

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Contents Noted

in the following analyses of five heats:

Element	%
Titanium	2.65 ± 0.04
Aluminum	2.01 ± 0.03
Carbon	0.14 ± 0.01

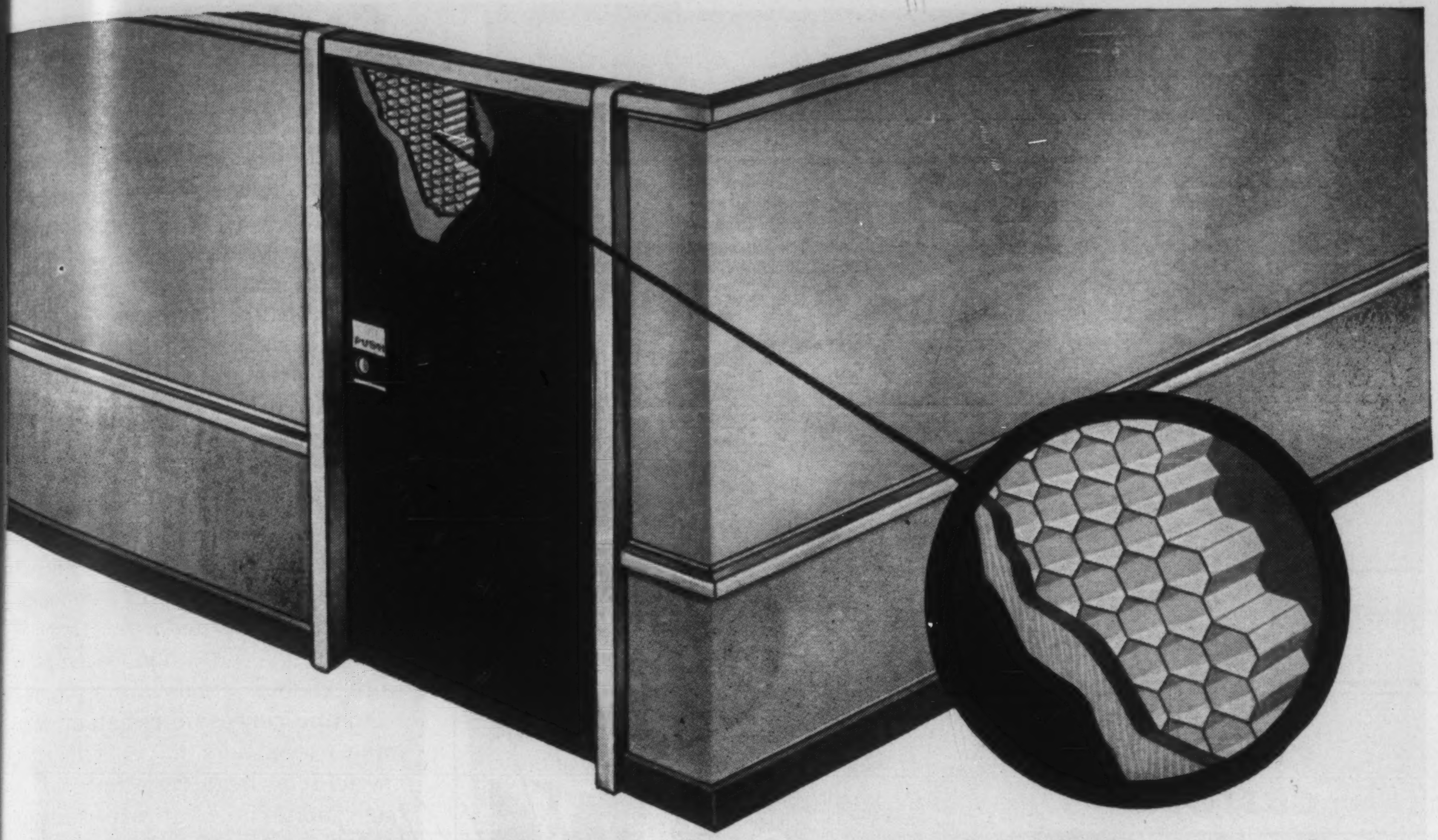
It seemed to be the concensus of the 250 engineers and scientists attending the symposium that though vacuum processing may not be the answer to every metallurgical problem, it is rapidly taking its place among the established commercial methods of production of high-quality materials.

Russians Report on Diffusion Coatings

A great deal of experimental work investigating both conventional and unusual diffusion coatings has been done recently in Russia. Most of reported data pertain to laboratory tests rather than commercial service, but possible practical uses can be imagined. In the May issue of *Werkstoffe und Korrosion* (German) W. Köhler summarized Soviet data published to date.

Of the conventional diffusion coating techniques investigated, the most interesting seems to be anti-corrosion nitriding of carbon steel. Non-porous, corrosion resistant nitrided layers can be formed on low-carbon unalloyed steels by exposure to a current of ammonia for 1½ to 3 hr at about 1000 F, or for 20 to 30 min at about 1300 F. Steels so treated have high resistance to water, damp air, combustion gases, oil, gasoline and weak alkaline solutions, but not to acids.

Aluminized steels are generally resistant to air and hot gases, but thin layers are likely to have low corrosion resistance because of porosity. Diffusion anneals are advantageous because they remove adhering chloride salts. Chromized mild steels are not as heat-resistant as aluminized steels, but they have good resistance to damp air, aqueous salt solutions and other mild corrosive media. Although siliconized steels have high resist-



Marvinol vinyl's beauty and practicality now in...

the honeycombed Kawneer door vinyl-laminated by the Marvibond process

Your doors are usually the visual focal point of inquiring visitors, and at the same time, the gateways through which they must pass—opening and closing, pushing and pulling. Because of this, Kawneer* now adds the beauty and practicality of Marvinol® vinyl to its functional triple-strength door. The vinyl is permanently bonded to the metal by the MARVIBOND† process, Naugatuck's exclusive technique for laminating vinyl to most metals.

Marvibonded metals offer the full, rich colors of vinyl in practically any surface effect—smooth or matte finishes, leather-like grains, marble patterns, prints, weaves, or other embossed finishes. And the Marvibond process adds to the strength, rigidity, and formability of metal, the abrasion resistance, chemical resistance, and weather resistance of vinyl... Marvinol vinyl which will not chip, scratch, or peel... nor support combustion. And, scuff-marks, fingerprints, and stains wipe off with a damp cloth.

Marvibonded metals are now being produced on a continuous production basis. Laminated before forming, they can be fabricated by all standard metal working tools—even deepdrawn without fracture or loss of adhesive bond.

If you are using sheet metals that have to be finished, or that would have added sales value if they were, why not investigate what Marvibond has to offer? **For samples, technical data, and the location of licensed laminators, please write to us on your company letterhead.**

†Patent applied for

*Kawneer Company, Architectural Products Division, Niles, Michigan

Naugatuck Chemical

Division of United States Rubber Company
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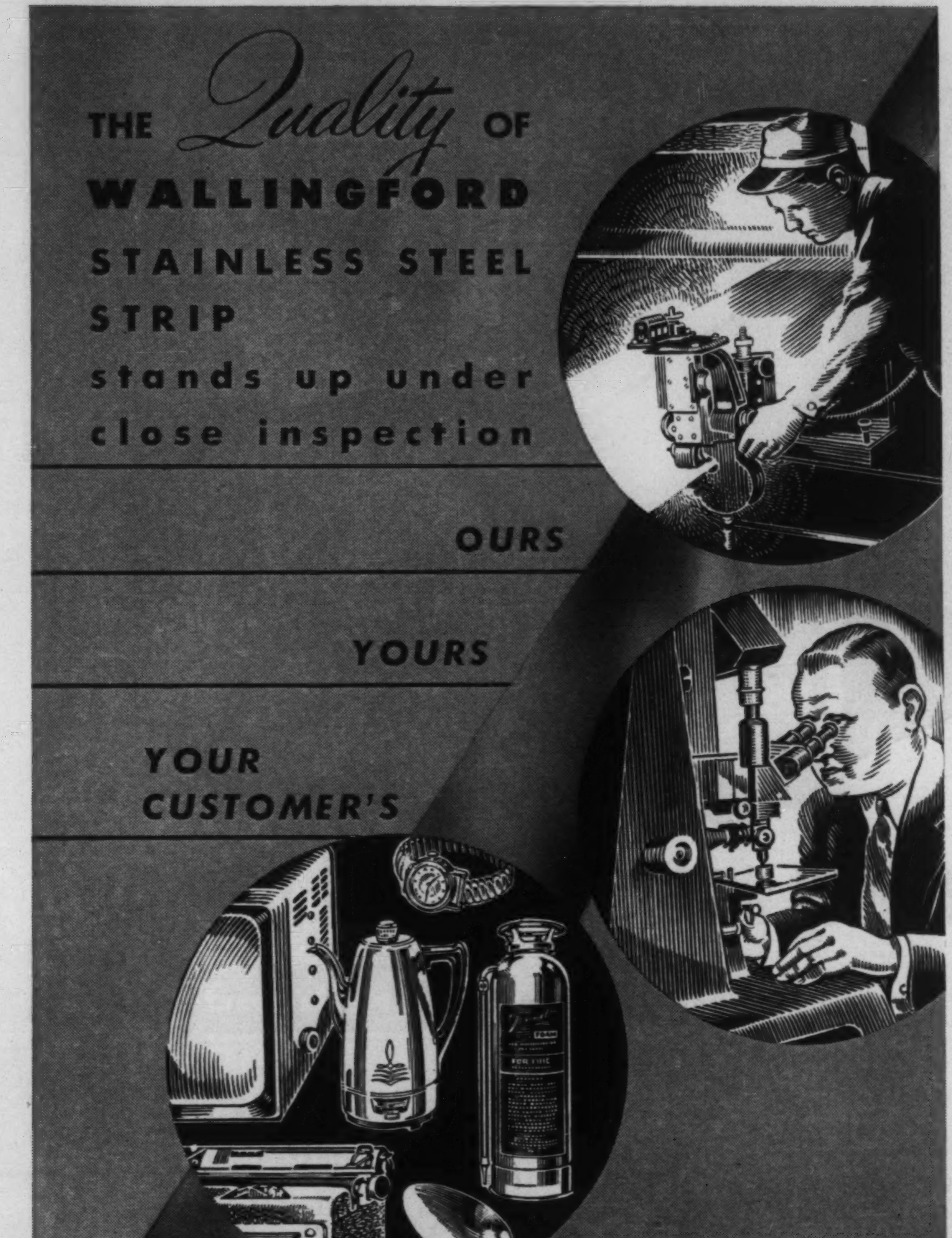

- THINNESSES TO .002".
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Even in this age of automation, quality is no "push-button" accomplishment. Modern machinery still must be teamed with skilled, experienced craftsmen to achieve the ultimate in quality. That's how it is at WALLINGFORD, and that's why WALLINGFORD Stainless Steel Strip stands up under the scrutiny of our advanced design electronic quality control devices . . . will meet your most rigid requirements for tolerance, analysis, temper, uniformity . . . and will pass the final test of customer usage and approval.
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ance to heat and corrosion, siliconizing does not improve oxidation and heat resistance as much as aluminizing.

Boron coatings are said to retain a high hardness after repeated heatings to 1740 F. They are also resistant to temperatures up to 1470 F and are not corroded by acids. Beryllium diffusion layers have a heat resistance almost equal to that of aluminized parts. Molybdenum and tungsten coatings have good resistance to mineral acids, while vanadium coatings show heat resistance up to 1470 F. Titanium coatings on high carbon steels are extremely hard and corrosion resistant. Manganese coatings have little effect on acid or heat resistance of the base material, but are resistant to hydrogen peroxide.

Some preliminary test data have been reported on duplex coatings such as chromium plus silicon, chromium plus nickel and chromium plus silver, but detailed results are not available. This may be a promising field for further exploration, since other combinations have proved quite successful. For example, a combination of chromium and aluminum is said to give better heat resistance than either chromizing or aluminizing.

Friction Materials in Oil

During and since World War II the need has grown for data concerning operating characteristics of friction materials in oil. The importance of this type of information is primarily due to the development of oil clutch supercharger drives for the aircraft industry and automatic transmissions for automobiles. Operating characteristics of friction materials in oil are different from those of dry friction materials, and new materials and techniques had to be developed. In a paper presented before the Golden Anniversary Summer Meeting of the Society of Automotive Engineers last June, J. F. Johnson of Raybestos-Manhattan, Inc., summarized the types of friction materials another case where

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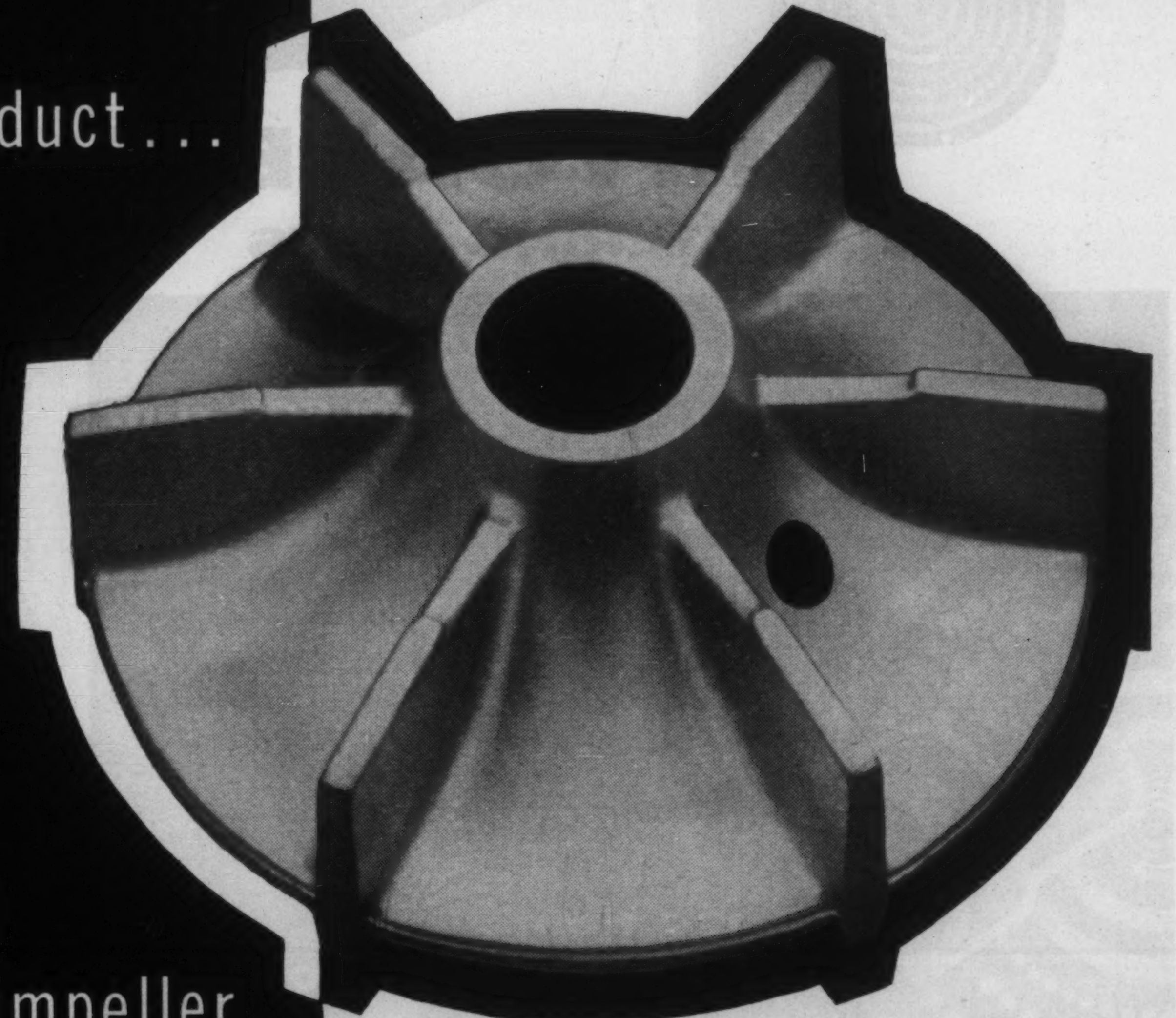
improve a product...



diesel engine
water pump impeller
forged of "603" **HIGH STRENGTH BRONZE**

Formerly produced as sand castings, these impellers now give better results because they're forged from "603" high strength bronze by the Mueller Brass Co. Said to be "right for the job and far superior to the old cast impellers", these forgings bring greater efficiency and longer life to the diesel engine water pumps in which they are installed. This tough "600" series alloy is readily forgeable, possesses remarkable resistance to corrosion, and has fine bearing qualities. Uniformity is excellent, due to the closer dimensional control of the forging process, and surface finish is noticeably smoother. This is another case where Mueller Brass Co. forgings have greatly improved a product . . . why not let our engineers show you the many advantages of using forgings.

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FIRST REPORT

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TELEMETERING TESTS

1660 hours

of high quality switching at **600 rpm**

March 29, 1955:
After 1660 hours of operation, the new Mycalex Model TM-55 Series Commutator Switch continues to function with a perfect and unchanging signal. This initial continuous test run was halted only to permit a simple brush cleaning — and the life test resumed. Test goal — **10,000 hours!**

170 hours

of uniform operation at **1,800 rpm**

A second test — running concurrently — and using the new Mycalex Model TM-55 Series brush construction provided a clean signal for 170 hours at 1,800 rpm! Once again, operation was halted only to permit brush cleaning — and the test resumed.

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- absolute dimensional and age stability
- imperviousness to moisture
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used in oil, their properties, characteristics and economies.

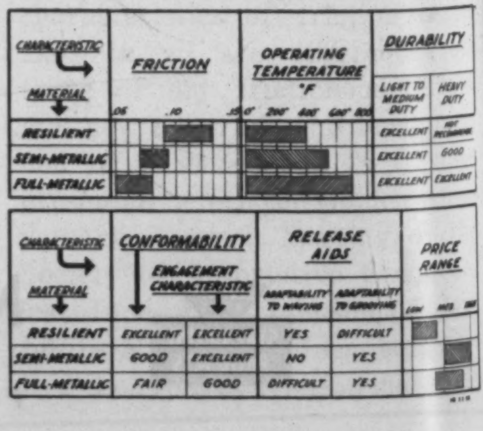
Classification of materials

Johnson described three general classifications of materials; resilient, semi-metallic and full sintered metallic. At present the most widely used of the resilient materials is a combination of cork and cellulose. Sponginess of this type of material makes for a slower build up in applying pressures with a built-in damping effect that tends to eliminate chatter and makes for smooth engagement. This type of material costs less than any of the other oil-use materials and properly designed will do a good job. They do have several definite limitations, such as pressure and temperature. Cork and cellulose materials char to destruction at 400 F. Also they have high "apparent wear" which is a loss of thickness due to both permanent set and true wear. Accompanying extreme permanent set is loss of resiliency which, in turn, brings about a slight dropoff in friction. These factors must be considered in design.

Another member of the family of resilient materials is the woven type, made up of asbestos and a binder. This material can withstand higher temperatures and is used primarily on both single and double wrapped bands running in oil.

Materials in the semi-metallic class are compounded from synthetic resins with 40% or more metallic powders in combination with asbestos and friction augments. These materials are used

USE FACTORS FOR FRICTION MATERIALS



CHARACTERISTIC → MATERIAL ↓	DURABILITY: LIGHT TO MEDIUM DUTY	DURABILITY: HEAVY DUTY
RESILIENT	EXCELLENT	NOT RECOMMENDED
SEMI-METALLIC	EXCELLENT	GOOD
FULL-METALLIC	EXCELLENT	EXCELLENT

CHARACTERISTIC → MATERIAL ↓	CONFORMABILITY	ENGAGEMENT CHARACTERISTIC	RELEASE AIDS: ADAPTABILITY TO WAVING	RELEASE AIDS: ADAPTABILITY TO GROOVING
RESILIENT	EXCELLENT	EXCELLENT	YES	DIFFICULT
SEMI-METALLIC	GOOD	EXCELLENT	NO	YES
FULL-METALLIC	FAIR	GOOD	DIFFICULT	YES

All-stainless kitchen, Carlton House, Pittsburgh, Pa.

Stainless shines in kitchen of Pittsburgh's Gateway Plaza.

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Leading fabricators like Ershler & Krukin, Bayonne, N. J., and their clients, know that for attractive, spick-and-span kitchens *all-stainless* equipment is the answer. And there's good reason for their choice of stainless steel. For *Crucible stainless* is a cinch to clean . . . foods can't discolor it . . . and its bright, smooth surface resists nicks and scratches through years of hard use. And it's easily fabricated by any standard method.

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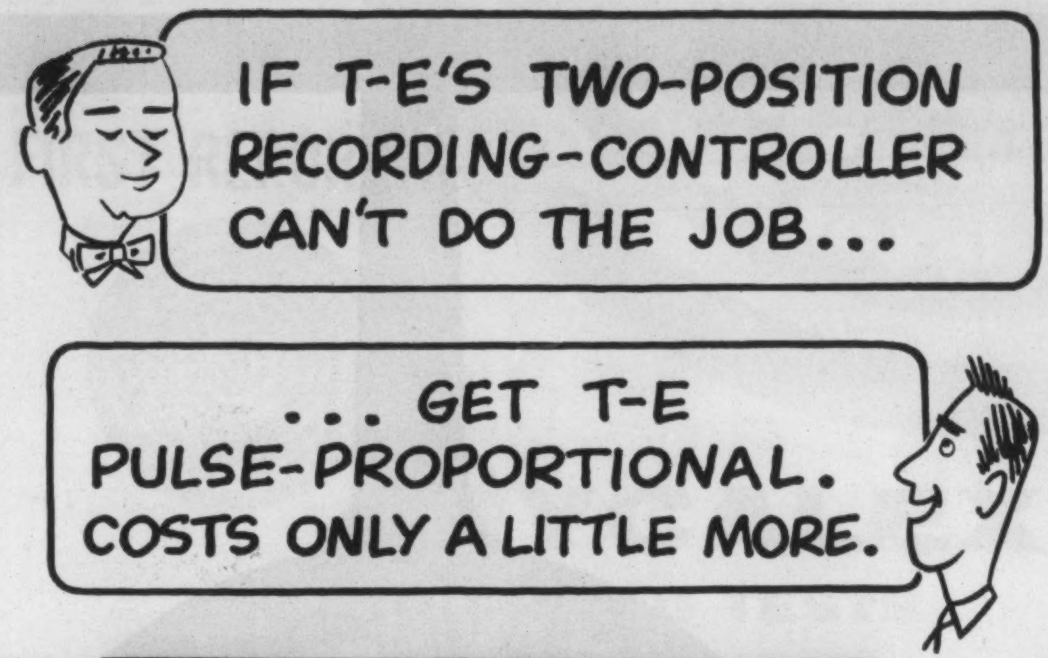
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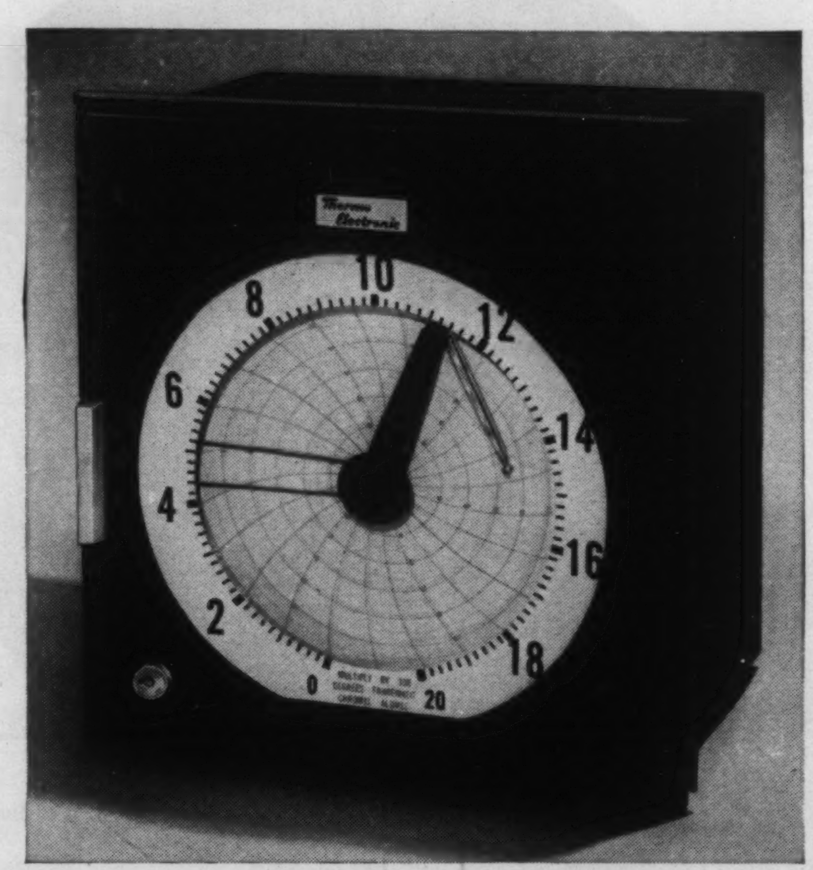

Thermo Electronic recording-controllers are relatively inexpensive instruments for recording and controlling temperature of electrically heated, fuel fired, or steam heated equipment. You can use them with two-position valves (electric or electric-pilot pneumatic types), contactors, or heavy duty relays. They will operate with thermocouples or resistance bulbs.

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Two types of controller: potentiometer pyrometer and resistance thermometer. Both are durable, simple, accurate, sensitive, speedy, and easy-to-set. 23 scale ranges from −320° to +200°F all the way up to 0° to 3000°F. The 12" recording chart is easy-to-read. ***Interested? Write for bulletin 62—G.***

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Contents Noted

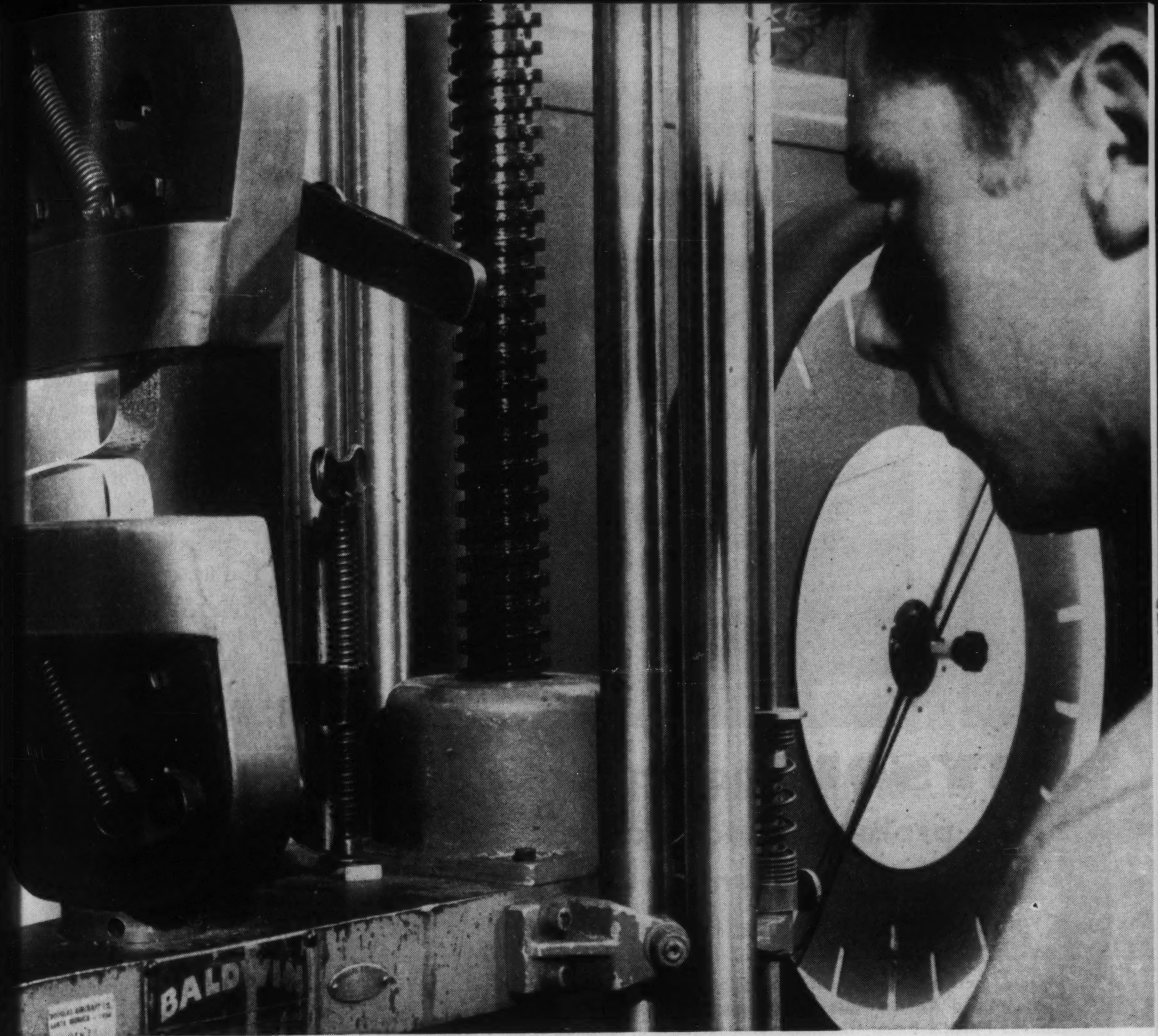
where temperatures and pressures are apt to be higher than those feasible for resilient materials. Skin temperatures on mating plates can be appreciably higher than 450 F and unit pressures have been encountered as high as 3000 psi. Engagement characteristics are excellent. Friction values of 0.065 to 0.10 place the materials lower than the resilient; however, they have much better durability. Semi-metallic materials are particularly well suited for use in the form of band plates, cones and intricate shapes. They can be machined or grooved to produce the best results with desired design characteristics.

Full metallic friction materials consist of sintered or fused metals combining friction-augmenting agents. Use of these materials allows much higher unit loading than with other types. They have a high rate of heat dissipation allowing them to operate under certain conditions with no increase in wear rate where other types of materials would wear at accelerated rates. Coefficient of friction is about 0.055 to 0.090, placing full-metallic materials below both semi-metallic and resilient types.

Selecting the material

Each of the three major divisions of friction materials has its own field of applications. In selecting the proper material there are eight use factors which must generally be considered. These are shown in the accompanying table with the relative ratings for each of the three classes of materials. Johnson concludes that the correct approach to the selection of proper materials is proper analysis, a correct marshaling of all known facts and a breakdown into factors of use. He also points out that there are other problems which must be considered such as flow of oil, type of oil, temperature of oil, types of finish on mating members and other important variables.

(More Contents Noted on p. 200)



Douglas Aircraft's new tear and peel tests prove versatility of 5000-lb. Baldwin machine

Douglas Aircraft Company finds their versatile Baldwin gives accurate, flexible testing in two new tests devised by them. At their Santa Monica, California Materials Laboratory tear and peel tests on titanium sheet and metal bonding adhesives, respectively, are being run on this 5000-lb. universal machine.

The tear test is used to determine usable quality sheet before release to the factory. It also measures brittleness, formability and strength. The test is conducted on the Baldwin by applying tension loads to a specially-prepared specimen engaged in steel hooks. By pulling the ears of the specimen, tearing originates at a pre-set point produced by a notch. The load increases until reaching the force required to start the tear from the notch. Then the load drops off rapidly or slowly in relation to the brittleness or ductility of the material. The load is autographically recorded along with the strain during the test.

Their peel test operation measures tensile strength of metal bonded specimens. Test panels are gripped in the jaws of the Baldwin machine and are peeled apart at a jaw separation rate of two feet per minute, separating the bond at a rate of one foot per minute. An autographic record versus crosshead motion is obtained. The test includes measurement of average adhesive film thickness and type of failure.

You too can count on Baldwin testing machines for versatile service . . . at safe, convenient operation. For further details write to Dept. 2823, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

TEAR TEST

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BLH
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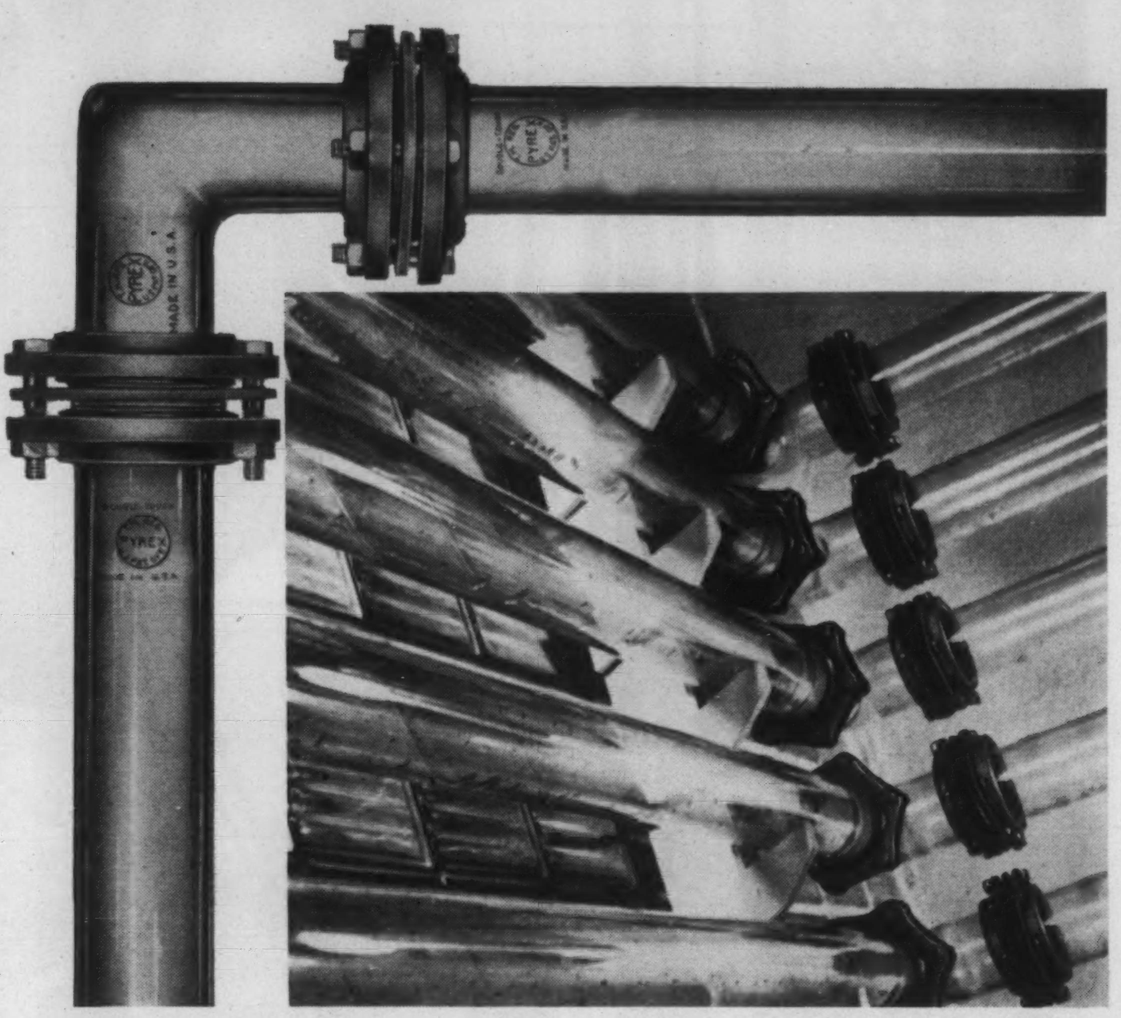
For more information, turn to Reader Service Card, Circle No. 391



HYSOL Epoxy Coating protects metal flanges used on Corning Glass PYREX Brand Glass Pipe

Again, the outstanding qualities of HYSOL Epoxy protective coatings are demonstrated by their use on the metal flanges used to connect the famous PYREX Brand Glass Pipe manufactured by Corning Glass Works, Corning, New York.

Tight joints between lengths of PYREX Glass Pipe are easily made with metal flanges which are cushioned from the glass by asbestos inserts. An interface gasket of rubber, asbestos or other material is gripped between the pipe ends when the flange bolts are tightened. There is no contact between the metal flanges and the fluid conveyed but flanges had to be protected against corrosion. That's why every metal flange is coated with a HYSOL Epoxy Coating by The Pioneer City Casting Company of Belpre, Ohio, manufacturers of the flanges, before they are shipped to Corning.

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For more information, turn to Reader Service Card, Circle No. 406

Contents Noted

Materials for Water-Lubricated Bearings

Many bearings in water-cooled nuclear power plants must be lubricated with high-purity water since organic lubricants react chemically under irradiation. Water lubrication poses new problems in the selection of materials for these bearings since fluid-film lubrication is a function of viscosity and the viscosity of water is only about 1/20 that of oil at 200 F. The problem is compounded by the fact that degassed, demineralized water is a corrosive medium. In general, the load-carrying capacity of a bearing operating in high-purity water is only a fraction of that of a similar oil-lubricated bearing. In a paper delivered before the Diamond Jubilee Semi-Annual Meeting of The American Society of Mechanical Engineers last June, A. Smaardyk of Argonne National Laboratory discussed some factors involved in selecting materials for, and designing water-lubricated bearings.

Though there is no hard and fast rule for selecting materials for water-lubricated bearings, selection is based primarily on two general properties: 1) wear compatibility and 2) corrosion resistance. Of the materials found to be optimum for this use, austenitic stainless steels, though desirable for their corrosion-resistance, were eliminated due to their galling and seizing characteristics. Nitrided or Malcomized materials showed the most resistance to galling. Materials used with Stellite 3 and 6 showed good results.

Since high-purity water is a corrosive medium whose attack on metals increases with temperature, bearing materials must resist corrosion at the 400-600 F operating temperatures of power reactors. The author reports that the best bearing material combinations for various types of bearings seem to be as follows:

Fluid-film bearings—Titanium carbide journal with carbon bearing.

Needle bearings—All Tantung

For more information, Circle No. 309 ➤

Contents Noted

G races and needles.

Ball bearings—All Stellite 3 races and balls.

Metal-to-metal—Nitrided type "W" and nitrided Armco 17-4 and 17-7 PH.

Reproducibility of Charpy Impact Test

There have been many published reports showing that the Charpy machine produces a wide scatter in energy values and in many cases a variation in energy values where two or more machines are used. These reports have led many to conclude that the Charpy impact test is not reproducible and therefore should not be used as an acceptance test. The Watertown Arsenal Laboratory, which has been obtaining reproducible results from the test for years, set up a test program to prove that the Charpy test is reproducible and therefore a reliable tool for inspection purposes. In a paper delivered before the annual meeting of the American Society for Testing Materials last June, D. E. Driscoll of Watertown Arsenal described the test procedure and results. The tests were carried out on two Charpy machines using specimens of 4340 steel which had been carefully checked for homogeneity to assure low variation in composition.

According to Driscoll, the investigation proved in general that wide scatter in results is due to poor steel quality, poor heat treatment, or both, and variations in machines are caused by poor testing techniques, poor condition of the machine itself, or possibly both. If the Charpy machine is in good working condition, properly calibrated, and proper testing techniques observed, over 90% of specimens tested should fall within a spread of ±1.0 ft-lb up to 20 ft-lb, and ±5 ft-lb above 20 ft-lb. The author reports that as a result of these surveys, Watertown Arsenal Lab and many private facilities concur in the feeling that when properly conducted, the Charpy test is truly an accurate and reproducible test.

(Book Reviews on p. 204)

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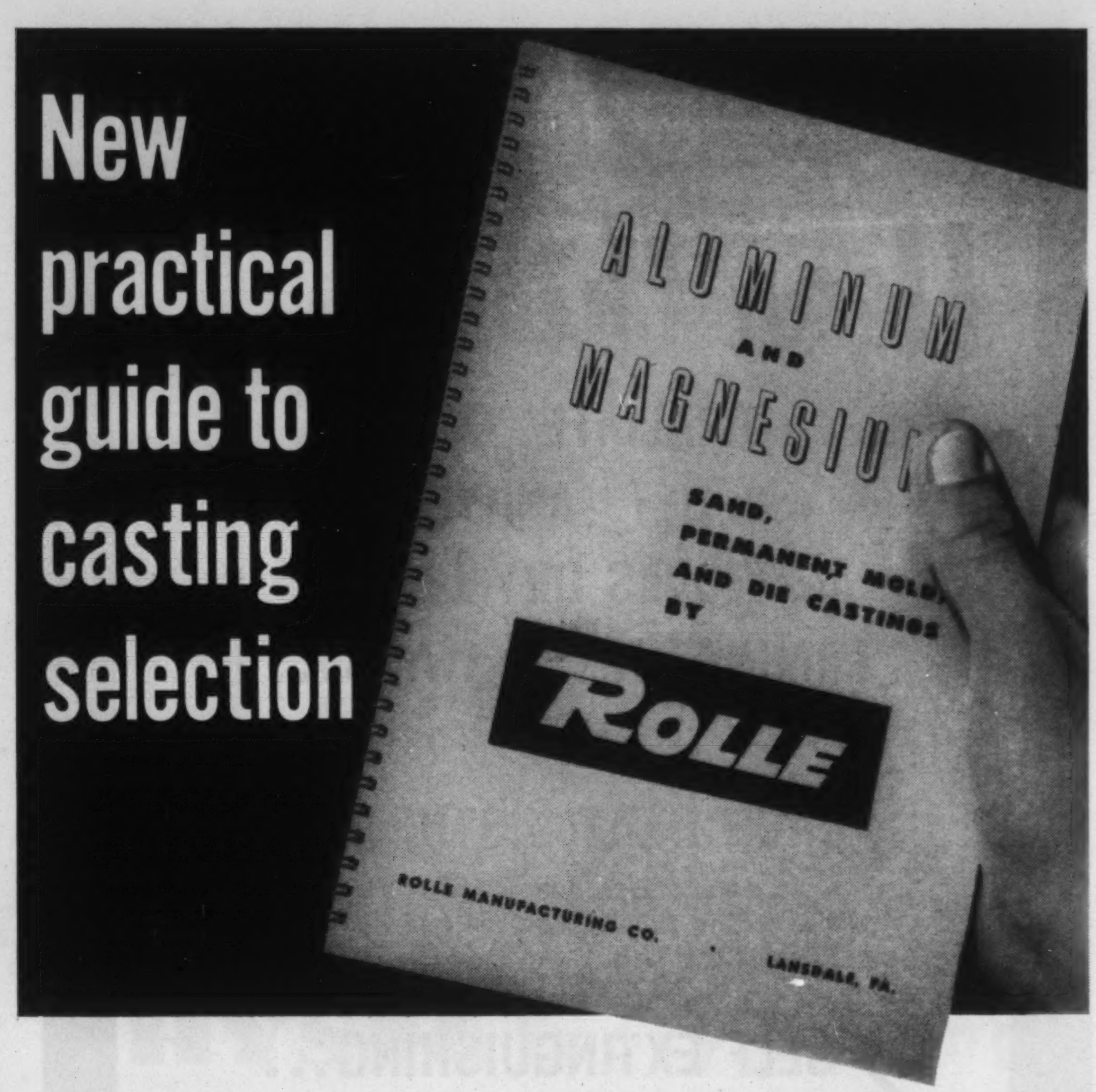
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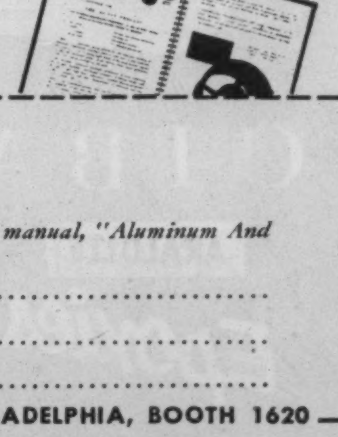

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Contents Noted

Books . . .

Vacuum Metallurgy. *The Electrochemical Society, Inc., New York 25, N. Y. 1955. Paper. 216 pp. Price $5.00.*

This volume contains the papers presented at the Vacuum Metallurgy Symposium held in Boston in October 1954, under the sponsorship of the Electrothermics and Metallurgy Division of the Society.

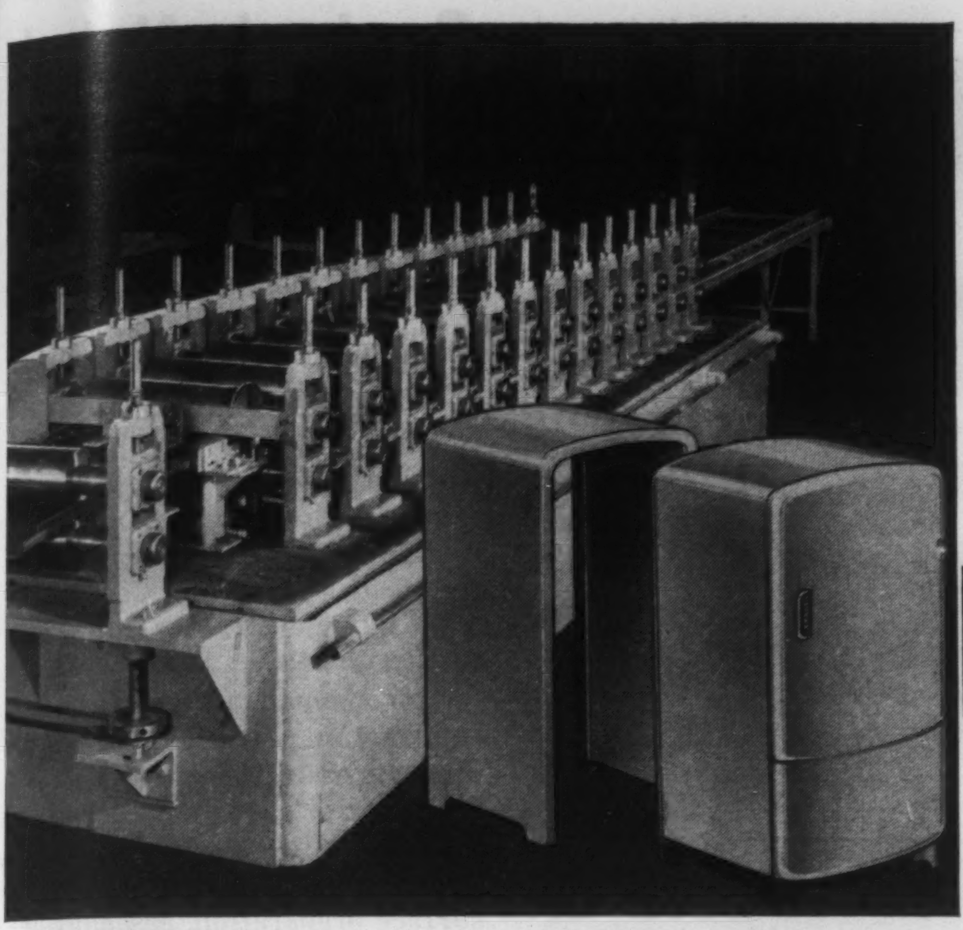
The book contains 19 papers covering such topics as vacuum melting, equipment for the production of high vacuum, properties of metals melted in a vacuum, vacuum heat treating techniques, vacuum distillation and determination of vapor pressures. (*See report on this symposium, p. 182*)

Design Manual for High Strength Steels. *H. Malcolm Priest and John A. Gilligan. United States Steel Corp., Pittsburgh, Pa. 1955. Cloth 6 by 9 in. 174 pp.*

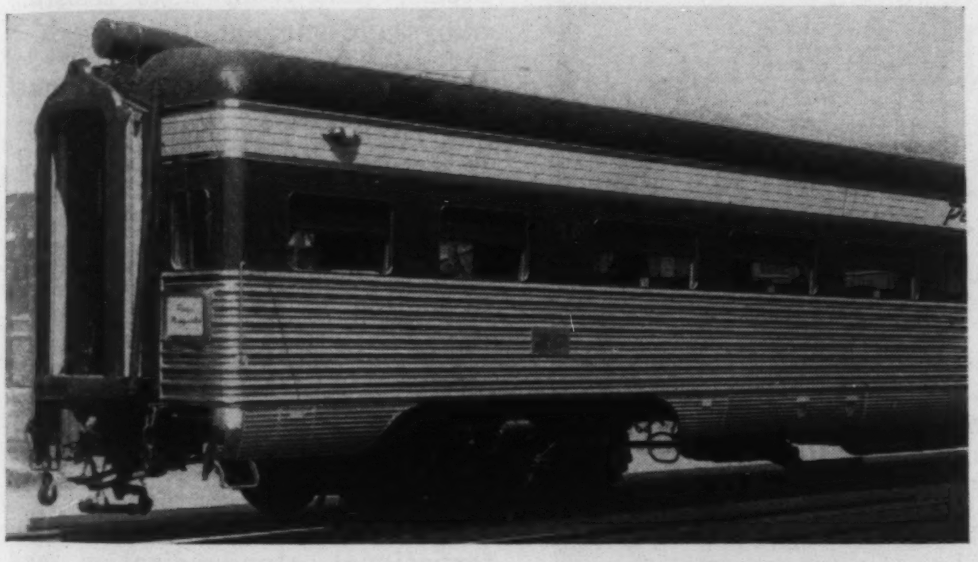
This is a practical handbook for architects and engineers which was compiled to provide information on the high strength low-alloy steels. Numerous charts and formulas are included not only for the high strength steels but also for structural carbon steel. Nomographic charts eliminate much of the time formerly required for design calculations. One section of the book is devoted to a discussion of design for effective resistance to corrosion.

Metals Reference Book, Second Edition. *Edited by Colin J. Smithells, Interscience Publishers, Inc., New York 1, N. Y. 1955. Cloth 6 by 9 in. 967 pp, 2 vol. Price per set $25.00.*

This reference book provides a convenient summary of data relating to metallurgy and metal physics in the form of diagrams and tables with a minimum of descriptive material. Extensive revision has been made in bringing out this second edition. New values have been substituted in the tables wherever recent reliable data have become available. Several sections have been entirely rewritten. Volume 1 contains 6 chapters on physics, an extensive section on



Refrigerator shells now being made almost exclusively in Yoder Cold Roll Forming machines, from flat sheets forming sides and top.



In autos, buses and railroad coaches, cold roll formed mouldings and panels serve many purposes, both inside and out.

Cold Roll Formed components enter extensively into this Stransteel home and many other factory-built structures.

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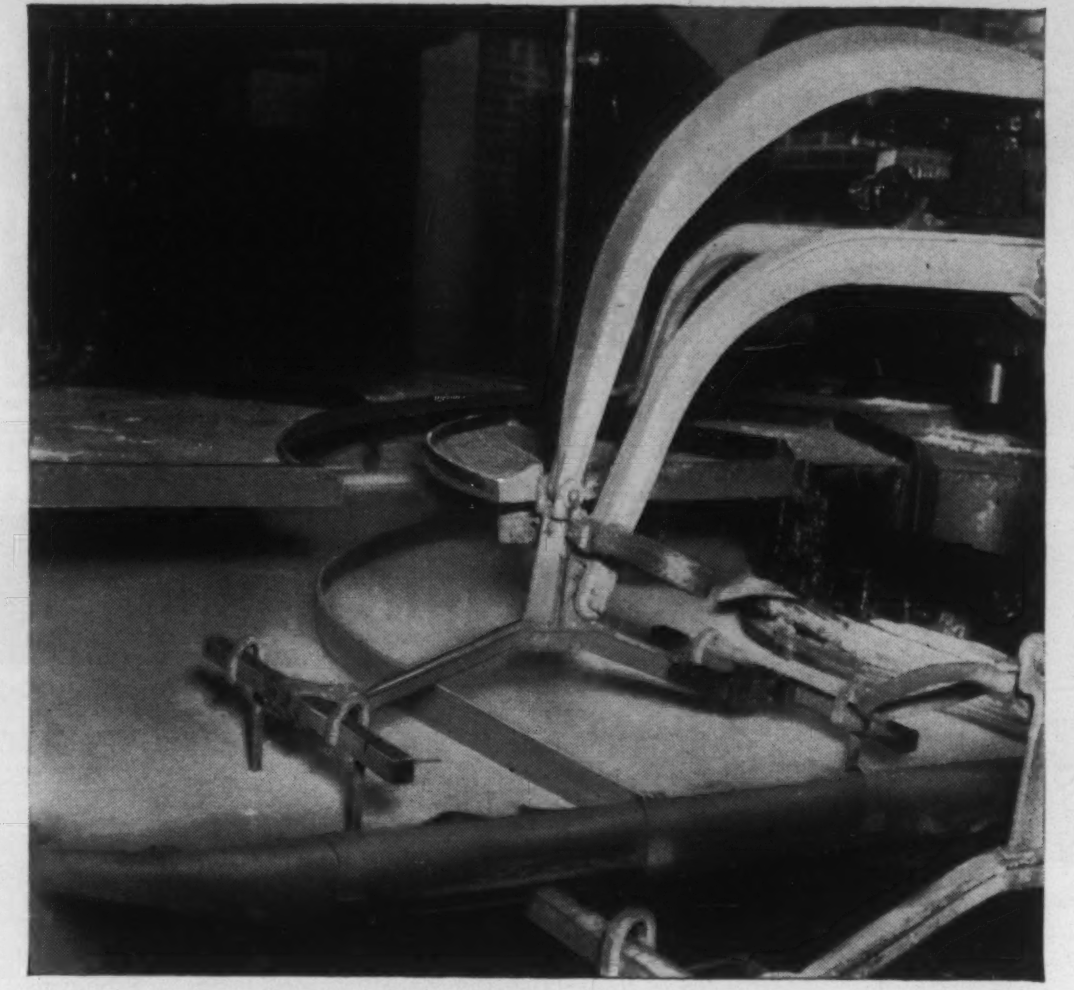

Better Soak-Cleaning in Automatic Plating Machines

Automatic plating equipment with short cleaning cycles have speeded up production but have multiplied headaches. One big problem, of course, is "How to clean work in as little as one minute without leaving insoluble deposits".

The key to thorough cleaning is fast wetting, since cleaning does not start until work is completely wetted. Thus if your automatic equipment has a one-minute cleaning cycle and it takes 30 seconds for the work to become thoroughly wetted, you have lost one-third of your cleaning time. The 30 seconds remaining is probably not sufficient time to remove all contamination.

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Not only does No. 909 get down to the cleaning job faster, but it also has stepped-up emulsifying power assuring that contamination will not be redeposited on work. No. 909 is completely soluble and free rinsing. Work comes out clean and soil free even with the short cleaning cycle of modern automatics. Contamination is not carried to subsequent solutions. Rejects are minimized.

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For more information, turn to Reader Service Card, Circle No. 463

Contents Noted

Books . . .

alloy equilibrium diagrams and a second on metallography. Volume 2 is devoted more specifically to the properties of metals although chapters on related subjects such as refractories are included also.

Brazing Manual. *Prepared by Committee on Brazing and Soldering, American Welding Society. Reinhold Publishing Corp., New York 22, N. Y. 1955. Cloth 6 by 9 in. 193 pp. Price $4.75.*

This manual presents practical information on all industrial brazing processes. Chapters describe the principles, the equipment and procedures involved in eight brazing processes, design of joints, surface preparation, assembly and inspection. Specific information is included on the brazing of aluminum alloys, copper alloys, various steels, cast iron, heat resisting alloys and various other metals.

Proceedings of the Third Annual Meeting, 1954. *Standards Engineers Society, Camden 1, N. J. 1955. Paper 8½ by 11 in. 48 pp. Price $3.00.*

This book contains the papers presented at the meeting of the Society in October 1954, on the subject of cooperation between government and industry on the development of standards. Topics include, the integration of military and industry standards, international standardization and American industry, place of standardization in management and suggestions on setting up and operating a materials department.

Atomic Energy Guidebook. *Walter A. Shead, Editor, The Atomic Energy Guideletter, Wash. 5, D. C. 1955. Paper 8½ by 11 in. 95 pp. Price $7.50.*

This book has been prepared to furnish nontechnical information on the atomic energy program. In it are discussed such topics as how to enter the atomic energy business, what are radioisotopes, what is a reactor, schools for nuclear study, governmental clearance required for access to classified information and the future of atomic energy. A valuable feature

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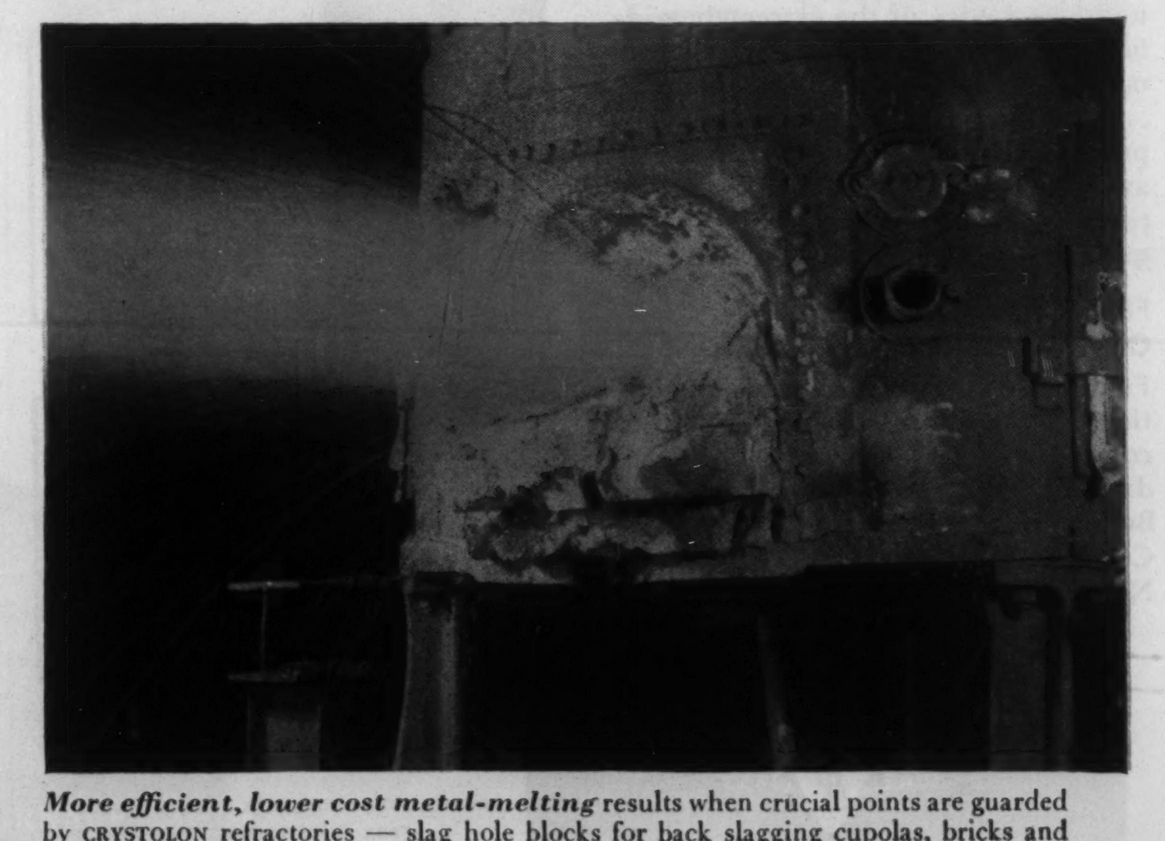

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Contents Noted

Books . . .

is a state directory of laboratories, libraries and contractors engaged in the nuclear energy program. A list of the manufacturers of atomic instruments is included also.

Reports . . .

Creep of Metal Lap Joints CREEP AND CREEP-RUPTURE CHARACTERISTICS OF SOME RIVETED AND SPOT-WELDED LAP JOINTS OF AIRCRAFT MATERIALS. Leonard Mordfin. National Bureau of Standards. June 1955. (NACA TN 3412). 53 pp, diagrams, photos, 6 tables. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Washington, D.C.

Equipment, test techniques, and results are presented for an experimental investigation of the creep of lap joints. Riveted aluminum-alloy joints fabricated from 75S-T6 and 24S-T3 sheet with 24S and 24S-T-31 rivets were tested at 300 F, 400 F, and 500 F. Spot-welded joints of ¼-hard, type 301 stainless steel were tested at 800 F. Each type of joint was also tested in tension at room temperature.

Plating Aluminum HARTVERCHROMUNG VON ALUMINUM (Hard Chromium Plating of Aluminum), by E. Meyer-Rässler. Translated and edited by F. A. Raven. Mar 1955. 26 pp. photos, table. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.25, Photocopy $4.00. PB 117354.

The hard chromium plating of aluminum parts can be carried out in baths of the same composition as those used for the chromium plating of steel and iron. Finishing of the hard chromium coating can only be acomplished by grinding and honing. The most important field of application of the hard chromium plating of aluminum is for the fabrication of internal combustion motor cylinders. For purposes of chromium plating, the cylinder is mounted in an arrangement in which the cylindrical

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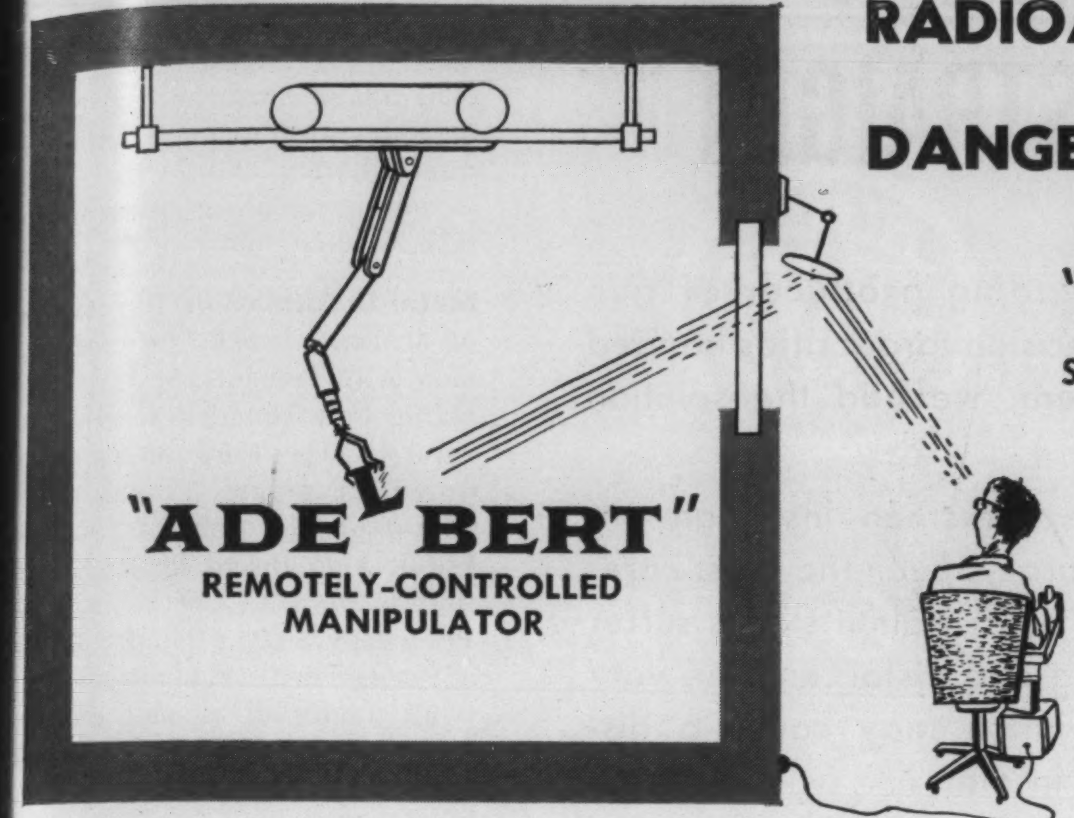

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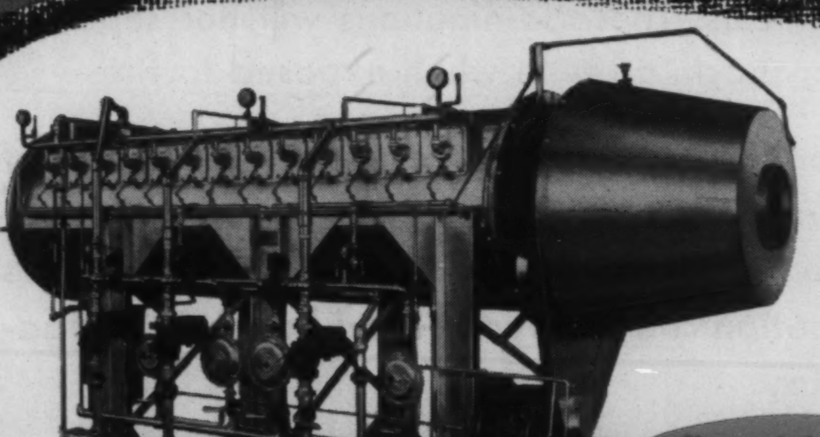

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For more information, turn to Reader Service Card, Circle No. 401

Contents Noted

Reports . . .

lead anode must be centered exactly in the interior of the aluminum cylinder. The thickness of the chromium plating ranges from 0.10 to 0.15 mm.

Metal Deformation DEFORMATION OF METALS UNDER COMBINED TENSION AND TORSION, by J. B. Tiedemann. U.S. Naval Research Laboratory. Mar 1955. 35 pp. photo, drawings, diagrs, graphs. Available from Library of Congress, Publication Board Project, Washington 25, D.C. Microfilm $2.50, Photocopy $5.25. PB 117333.

Permanent elongations and twist angles of slender rods and tubes of aluminum, copper, and steel, under the influence of constant torque and increasing axial load, have been studied to establish the orientation of the principal strain axes under combined stress. It was found that the principal axes of plastic strain coincide with the principal axes of stress for annealed materials, but for drawn materials there is substantial divergence.

DEFORMATION STUDIES OF METALS AT ELEVATED TEMPERATURES. II. Iron - Chromium - Nickel Ternary System. III. Effect of structure and composition on the strength properties of stainless steel, by N. J. Grant, H. C. Chang, F. C. Monkman, and Peter Price. Massachusetts Institute of Technology. Dept. of Metallurgy. May 1954. 6 pp. table. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $1.50, Photocopy $1.50 PB 117129.

Titanium DEVELOPMENT OF TITANIUM ALLOY POWDER PRODUCTION. Interim Technical Report, Aug 15, 1951 to Feb 28, 1953, under Contract No. DA-33-019-ORD-328 by Harry W. Dodds. Brush Development Co., Cleveland, Ohio. Feb 1953. 24 pp. photos, tables. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.25, Photocopy $4.00. PB 117334.

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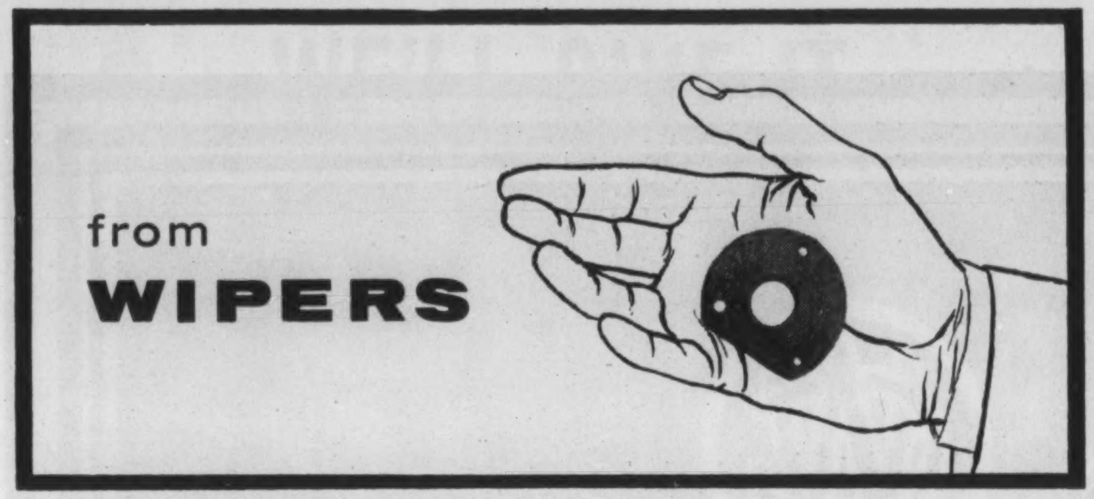

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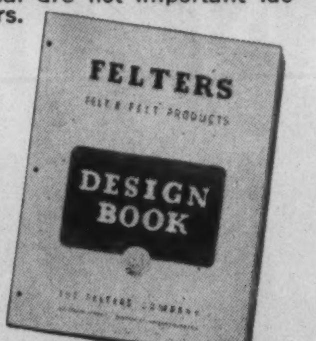

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Contents Noted

Reports . . .

tion of titanium alloy scrap has involved the following investigations: (a) mechanical disintegration by use of an attrition mill, (b) powdering by mechanical disintegration through use of a mutilator, and (c) hydriding. Protective precautions believed necessary in industry if scrap is to be made reusable are also suggested.

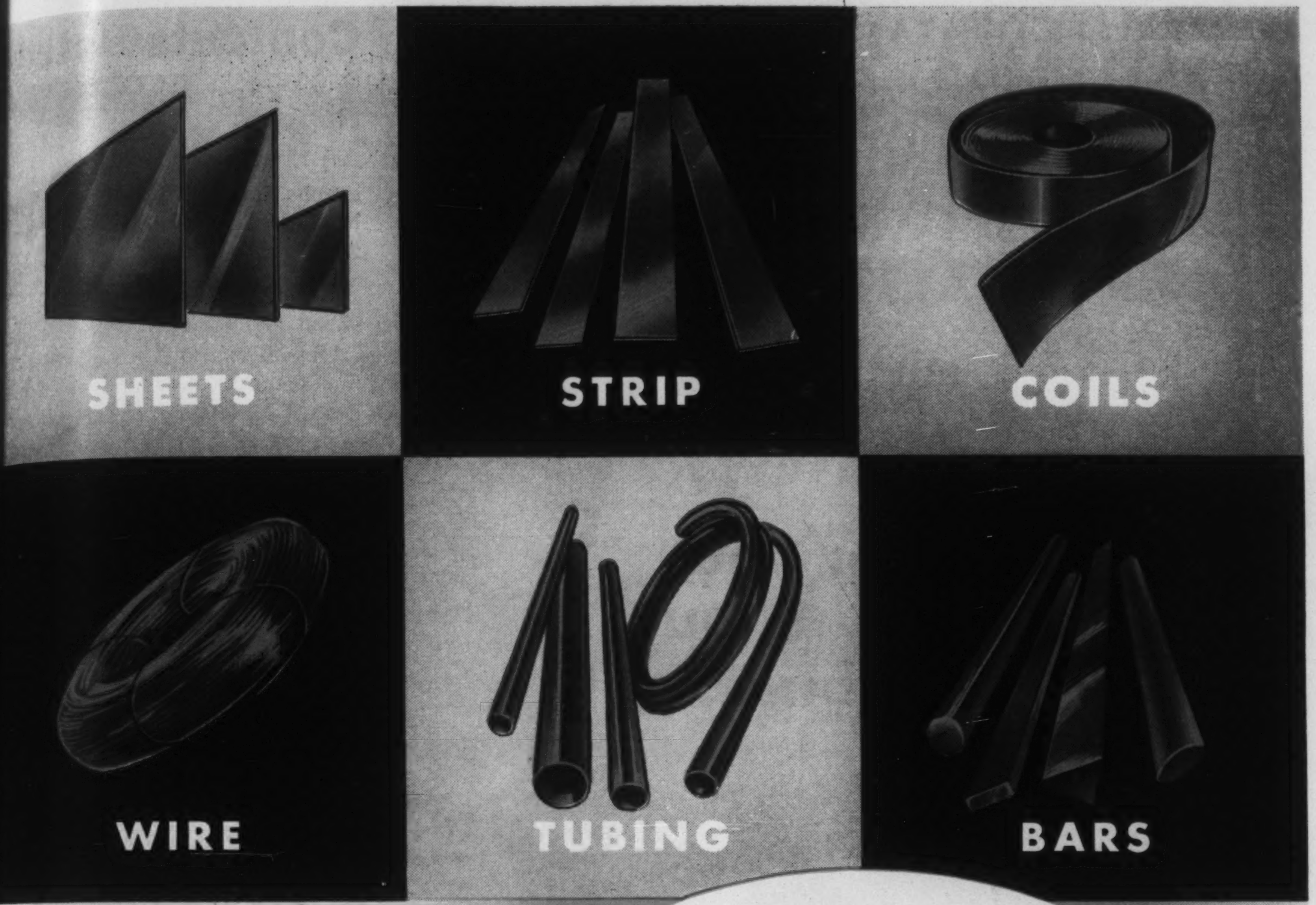
GRAIN GROWTH AND RECRYSTALLIZATION IN TITANIUM AND ITS ALLOYS, by Edward L. Bartholomew, Jr. Connecticut University. Dept. of Mechanical Engineering, Storrs, Conn. Jun 1954. 70 pp. photos, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $1.75. PB 111627.

This project covers the influence of temperature, time, amount of cold deformation grain size on grain size of cold work and annealed titanium (RC-55) and three alloys, Ti-100A, Ti-150A and RC-130A. Results of isothermal annealing microstructural studies to determine the kinetics of recrystallization and mechanisms of grain growth in cold rolled and annealed titanium (RC-55) are also reported.

Flaw Detection in Nickel Plates POROSITY OF NICKEL DEPOSITS BY AUTO-RADIOGRAPHIC TECHNIQUE, by Russell H. Wolff and Mary Ann Henerson, U. S. Arsenal, Rock Island, Ill. Mar 1954. 37 pp. photos, graphs. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.50, Photocopy $5.25. PB 117368.

A non-destructive, reproducible test is described for the determination of flaws in both electrodeposited and electroless coatings of nickel.

Rubber Research PROCEEDINGS, JOINT ARMY-NAVY-AIR FORCE CONFERENCE ON ELASTOMER RESEARCH AND DEVELOPMENT, the Pentagon, Jan 12 and 13, 1954, sponsored by the Office of the Quartermaster General, conducted by the Advisory Board of Quartermaster Research and Development. Sep 1954. 148 pp. photos, diagrs,



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Contents Noted

Reports . . .

graphs, tables. Available free from NAS-NRC Publications Office, 2101 Constitution Ave., N. W., Washington 25, D. C. PB 117130.

Wood PROPERTIES AND USES OF TROPICAL WOODS, IV, by Frederick F. Wangaard, Arthur Koehler, and Arthur F. Muschler. Yale University. School of Forestry, New Haven, Conn. Apr 1954. 190 pp. photos, tables. Available from Yale University, School of Forestry, 205 Prospect St., New Haven 11, Conn. $1.00. PB 116772.

Fatigue at High Temperatures COOPERATIVE INVESTIGATION OF RELATIONSHIPS BETWEEN STATIC AND FATIGUE PROPERTIES OF WROUGHT N-155 ALLOY AT ELEVATED TEMPERATURES, by NACA Subcommittee on Heat-resisting Materials. U. S. National Advisory Committee for Aeronautics. Apr 1955. 92 pp. photos, drawings, graphs, tables. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N. W., Washington 25, D. C. PB 117070.

German Nylon GERMAN PROTECTIVE SHEETS, NYLON TYPES, by Harold L. Pachernik. U. S. Chemical Warfare Service. 40th Chemical Laboratory Co. Nov 1944. 22 pp. photo, table. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.25, Photocopy $4.00. PB 117293.

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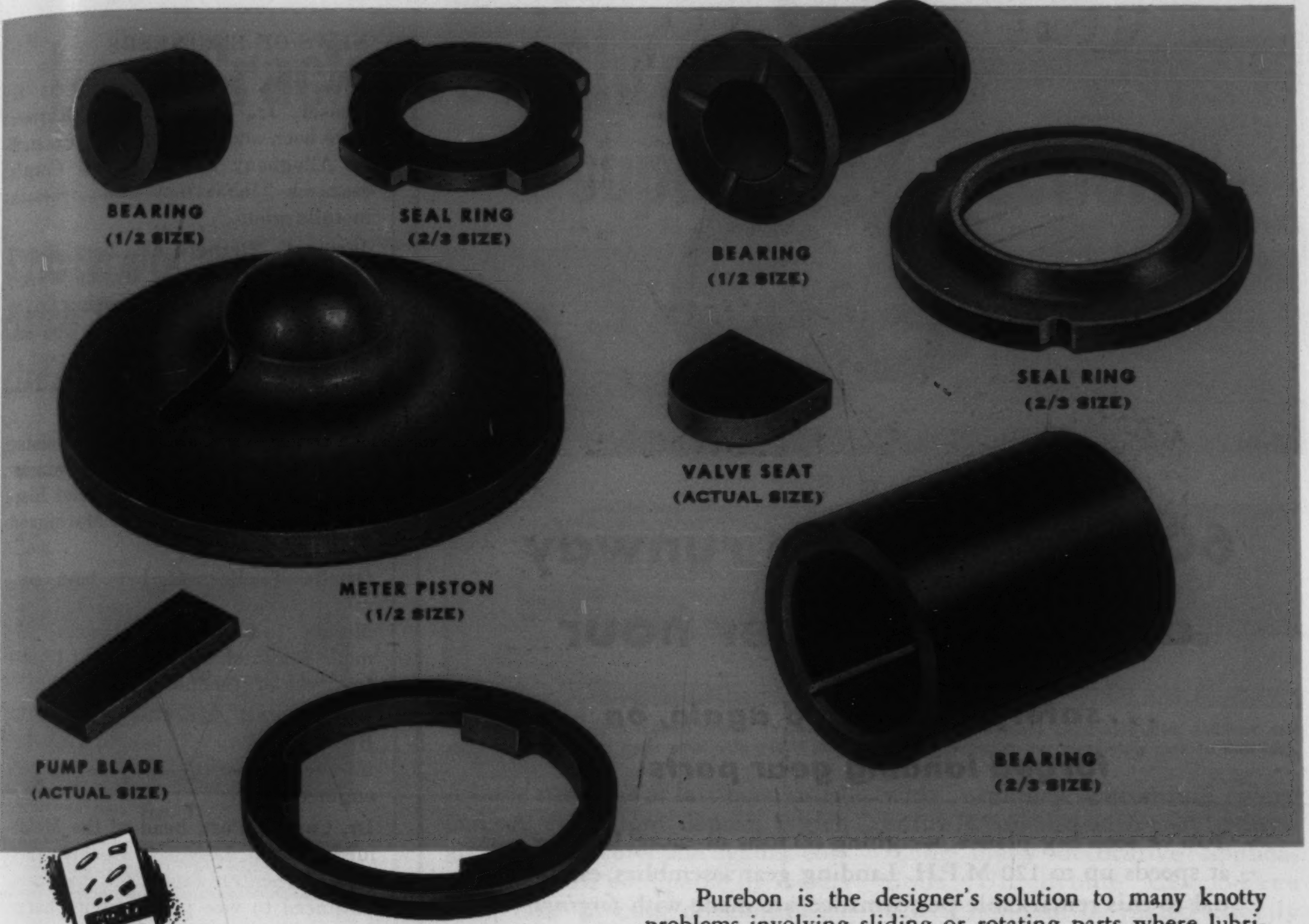
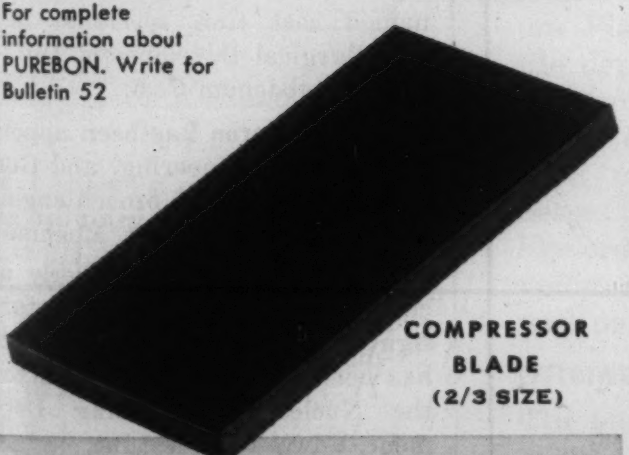

BEARING (1/2 SIZE)
SEAL RING (2/3 SIZE)
BEARING (1/2 SIZE)
SEAL RING (2/3 SIZE)
VALVE SEAT (ACTUAL SIZE)
METER PISTON (1/2 SIZE)
PUMP BLADE (ACTUAL SIZE)
BEARING (2/3 SIZE)
SEAL RING (ACTUAL SIZE)

For complete information about PUREBON. Write for Bulletin 52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Purebon is the designer's solution to many knotty problems involving sliding or rotating parts where lubrication is difficult and sometimes impossible. Purebon parts are molded or machined exactly to our customers' specifications here in our own plant, under our close supervision and inspection. *Because of the diversified characteristics of Purebon, applications are limited only by the designer's imagination.* If you have a problem involving insufficient lubrication at critical points of friction, our design engineering department will be happy to work with you toward its swift and successful solution.

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1 ***MOLDED TO SIZE—FOR MANY APPLICATIONS***
Tolerances of approximately 1½% of dimension required for molding most shapes.

2 ***SELF-LUBRICATING—OR BY THE MATERIAL HANDLED***
Varies with grade of Purebon.

3 ***STRONG AND TOUGH***
Transverse strength varies from 4,000 to 13,000 lb./sq. in. according to grade.

4 ***READILY MACHINABLE***
Tolerances as close as .0005 can be maintained where required.

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Resistant to attack by chemicals of all kinds, used in food handling and processing equipment.

6 ***HIGH TEMPERATURE APPLICATION***
Most Purebon grades will operate efficiently in temperatures up to 700°F in air or much higher in neutral or reducing atmosphere.

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news of ENGINEERS COMPANIES SOCIETIES

NEWS OF ENGINEERS

Robert H. Kaltenhauser, John E. **Mosser, Jr.,** and **David L.** Raymer have been added to the technical staff of Allegheny Ludlum Steel Corp.'s research laboratory as research metallurgists.

James C. Barnett has been named plant engineer at the Boston Works, Allis-Chalmers Manufacturing Co., to succeed **N. William Morelli** who has been transferred to a similar post at the company's Terre Haute, Ind., Works.

Walter T. Buhl has been appointed vice president in charge of engineering and manufacturing, Leland Electric Co. Div., American Machine & Foundry Co.

Orville T. Barnett has been promoted to assistant manager of the Metals Research Department, Armour Research Foundation of Illinois Institute of Technology.

Ernest Port recently joined The Brunswick Balke Collender Co.'s Reinforced Plastics Div. as project engineer.

Dr. Carl B. Post, head of the Metallurgical and Research Departments, The Carpenter Steel Co., has been advanced to vice president in charge of metallurgy.

Herbert Geittman, Jr., has been named cast iron specialist in the Metallurgical Development Div., Climax Molybdenum Co.

George Cameron has been appointed director of engineering, and **Gordon Cook,** supervisor of broach engineering, Colonial Broach & Machine Co.

Abraham Smaardyk, formerly associate engineer in nuclear reactor design at Argonne National Laboratory, has been made associate director of the Nuclear Engineering Department, Edward Valves, Inc.

David Swan has been named director of research, Metals Research Laboratories, Electro Metallurgical Co.

G. Frederick Dietz, Jr., and **Richard N. Mackinnon** have been appointed industrial engineers in General Electric Co.'s Laminated and Insulating Products Department. In addition, another appointee, **Dr. Wen Hsiang Chang,** recently joined the Materials and Processes Laboratory of the

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic . . . . Organic . . . . Decorative . . . . Protective

New Crack-Free Chromium Plate gives superior protection

Structurally perfect finish from stress-free chromium

Differences in the structure of ordinary chromium and Crack-Free Chromium deposits are shown by the photomicrographs below.

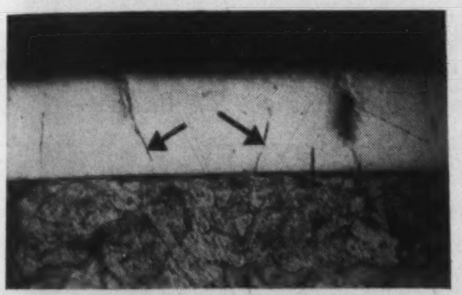

Fig. 1

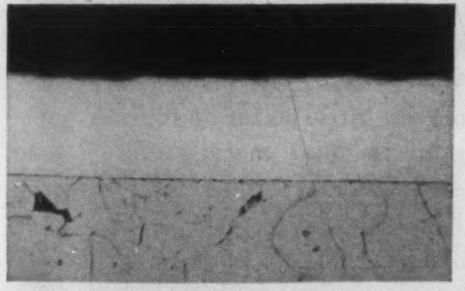

Fig. 2

Figure 1 shows a cross section of etched ordinary chromium .00125″ thick, with part of its network of cracks. Note that some cracks extend through the deposit to the base metal, providing an unimpeded path for corrosives.

Figure 2 shows a section of etched Crack-Free Chromium also .00125″ thick. Note the complete absence of cracks.

• • •

UNITED CHROMIUM DIVISION
METAL & THERMIT CORPORATION
100 East 42nd Street, New York 17, N. Y.
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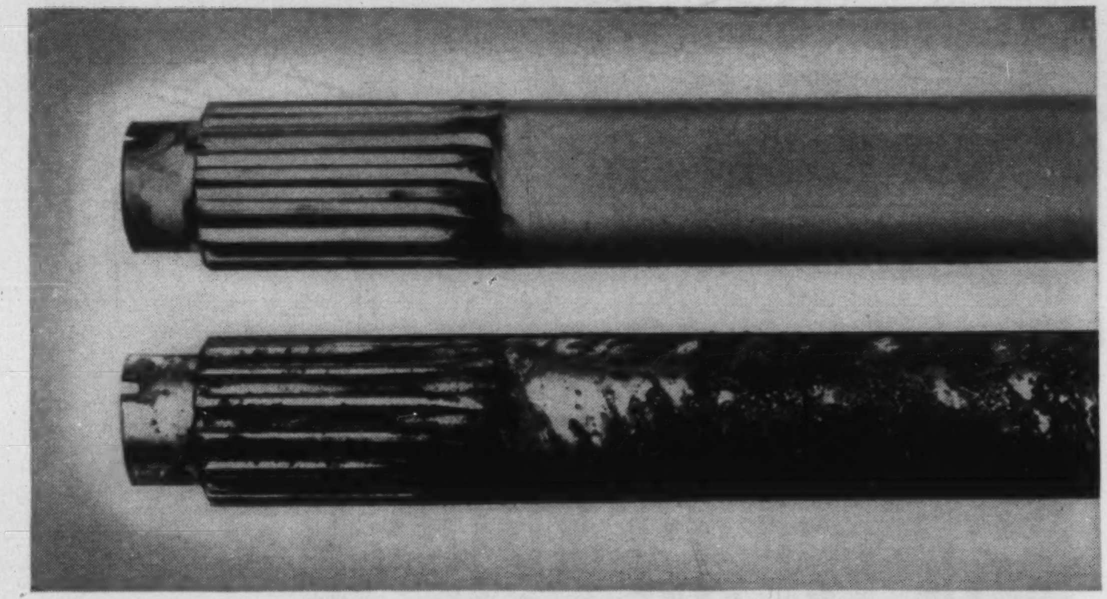
East Chicago, Ind. • El Segundo, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.



Upper steel shaft, with 0.0005 inch of Crack-Free Chromium, was virtually unaffected after 100-hour salt spray test. Surface of lower shaft with 0.0005 inch of ordinary chromium was completely covered with rust.

A basic need has at last been satisfied. A chromium deposit which gives better protection against corrosion is now obtainable by means of a new process developed by United Chromium.

Unichrome Crack-Free Chromium Plating produces more ductile deposits which are relatively free from internal stress. Thus, deposits do not crack as they are built up to hard plating thicknesses. In this respect they are unlike ordinary chromium which develops cracks, providing corrosives with paths to the underlying metal.

EFFECTIVE PROTECTION DIRECTLY ON STEEL

The photograph above shows that .0005″ of Crack-Free Chromium plated directly on the steel prevented rusting of shafts subjected to 100 hours of salt spray, while the same thickness of ordinary chromium failed completely.

In other corrosion tests, parts plated with .0003″ of Crack-Free Chromium were as good as new after a full year at 100% relative humidity and 110°F whereas parts with ordinary chromium were entirely covered with rust in days.

For many decorative applications, Unichrome Crack-Free Chromium can be plated directly on steel or zinc base die castings, eliminating need for scarce nickel.

OTHER BENEFICIAL PROPERTIES

Crack-Free Chromium deposits are hard (500 to 700 Knoop), have a low coefficient of friction, and a non-galling, non-seizing surface. The plate has superior ductility and resistance to thermal shock. Unusual leveling action is provided by the solution.

Its grayish, matte finish needs buffing for high luster, but this is done as readily as buffing dull nickel. Attractive two-tone effects can be produced by buffing some areas, leaving others as plated.

Unichrome Crack-Free Chromium has already proved its advantages for hard chromium plating and certain decorative applications in successful commercial operations. Bulletin CFC-1 gives more details. Send for your copy.

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Magline Inc.—one of America's leaders in magnesium—has prepared a descriptive new bulletin, expressly outlining for designers and engineers, the company's services as a reliable, experienced source for magnesium castings, fabrication and complete production. Specialists in magnesium exclusively, Magline's background and experience will serve you well in three important ways: (1) Objectively searching out ways to improve your product through the application of magnesium; (2) Assisting in the design and development phases; (3) Producing the required parts and components in any quantity, to your exact specifications. May we send you a copy of Bulletin No. 50.

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For more information, turn to Reader Service Card, Circle No. 425

news of | ENGINEERS

company's Large Steam Turbine-Generator Department as an applied research engineer.

Frank Breckenridge has been made vice president in charge of engineering and manufacturing operations for Globe Hoist Co.'s three plants at Philadelphia, Des Moines and Long Beach, Calif. Mr. Breckenridge has also been elected to serve on Globe's board of directors.

Arthur Townhill has assumed the position of director of engineering, Harvill Corp.

Dr. John M. Clegg and **Dr. Arthur Katchman** have been added to the technical staff of the Research and Development Department, Hooker Electrochemical Co.

Louis J. Petti has joined the Research and Development Staff, Houghton Laboratories, Inc.

Alvin J. Silverman has been named chief engineer, and **Maurice Hayden**, propect engineer, Induction Motors, Inc.

J. N. Wolfram has been made engineering manager, The Parker Appliance Co.

Dr. Daniel W. Elam has assumed direction of the newly-established Adhesives Engineering Div., Hexcel Products, Inc.

Ronald L. Loup has been appointed director of the Development Engineering Div., Progressive Welder Sales Co.

Forrest Stretmater has been promoted to chief metallurgist, Servel, Inc.

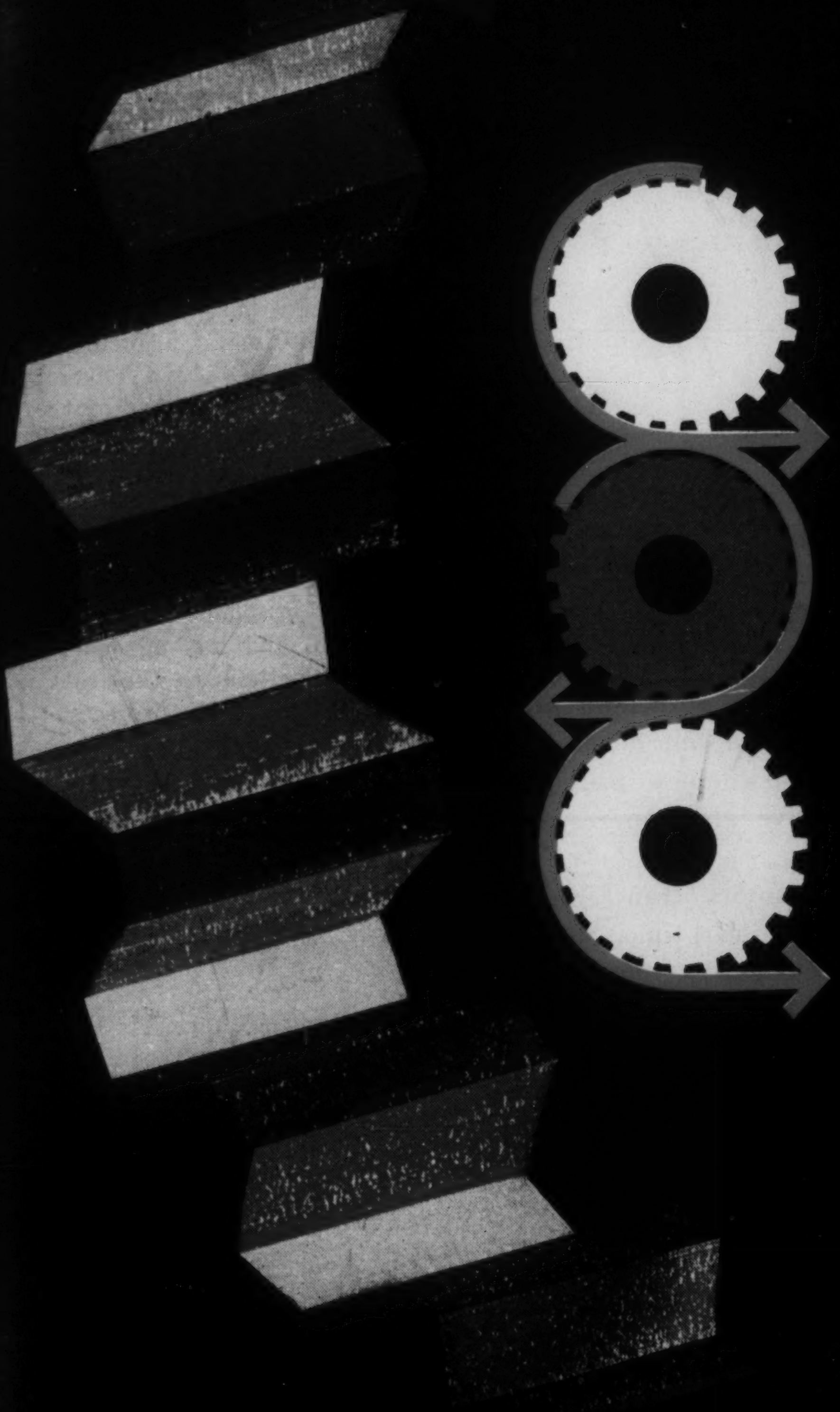
Albert E. Manofsky has been named chief engineer, Sherman Products, Inc.

Richard B. Johnson has been appointed a production engineer, Superior Tube Co.

Devereaux Martin has been made vice president and director of engineering, Viking Instruments, Inc. In his new position Mr. Martin will direct development and research on the company's line of electronic devices and controls for industry.

V. B. Baker has been given the newly-created position of assistant engineering manager, Executive Department, East Pittsburgh divisions, Westinghouse Electric Corp. Other new appointments by Westinghouse include **D. W. Berry** as assistant chief engineer of the Aviation Gas Turbine Div., and **D. R. Tashjian** as manager of engineering, Electronics

4150 steel is your best bet for heavy sections



Chromium Molybdenum Steel like AISI-SAE 4150 is the most economical way to uniform properties throughout heavy sections. For heavy duty gears — for shafts — wherever toughness and fatigue strength are important, *plentiful* 4100 Moly steels are better. We will prove it. Climax Molybdenum Company, 500 Fifth Ave., New York 36, N. Y.

AISI-SAE 4150

C 0.48/0.53	Mn 0.75/1.00	Pmax 0.040	Smax 0.040
Si 0.20/0.35	Cr 0.80/1.10	Mo 0.15/0.25	

4100 steels are your best bet

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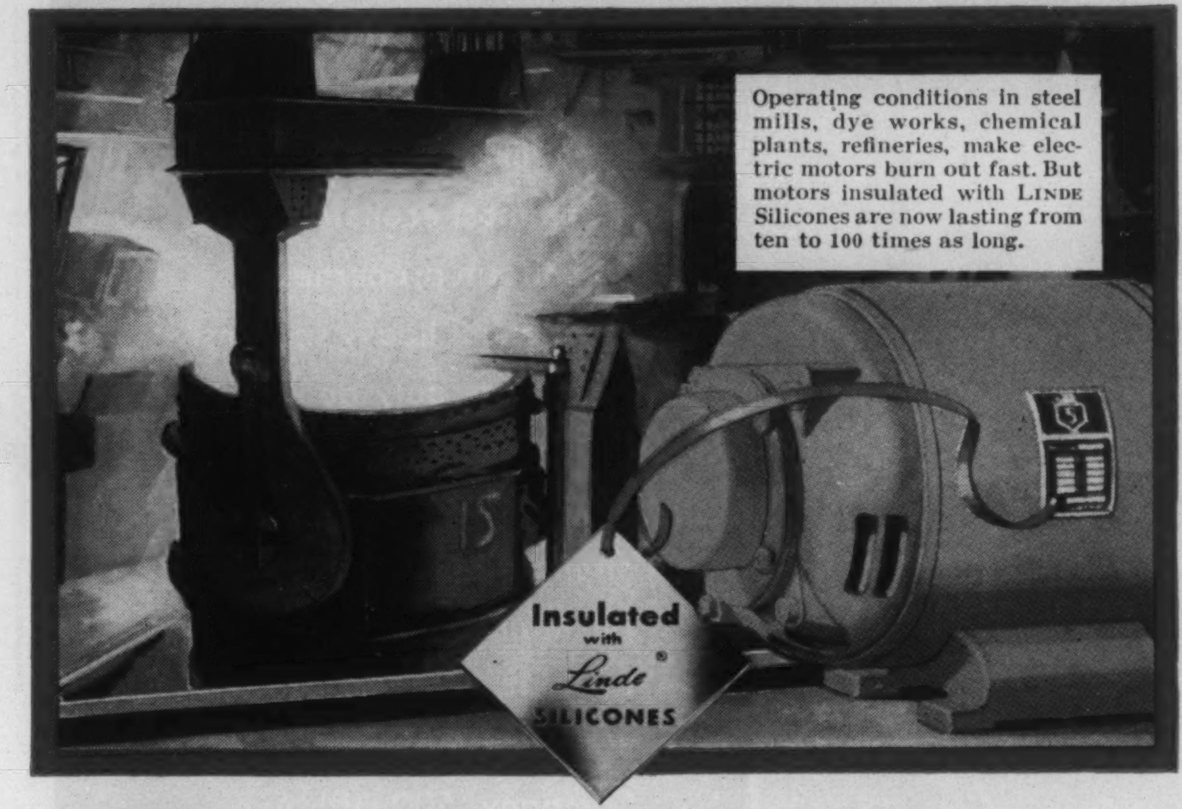
LOOK HOW

Linde TRADE-MARK silicones toughen up electric motors



Operating conditions in steel mills, dye works, chemical plants, refineries, make electric motors burn out fast. But motors insulated with LINDE Silicones are now lasting from ten to 100 times as long.

LOOK AT the reasons why

Electric motors insulated with LINDE Silicones withstand high heat caused by overloads, frequent starts, and hot locations—prime causes of motor burn-outs. This dependable new insulating material also resists water, ozone, corrosive atmospheres and many strong chemicals.

Insulated with silicones, your electric motors, transformers, solenoids and other apparatus seldom cause down time. Specify this insulation on new equipment. Have your existing equipment rewound with Class H insulation based on LINDE Silicones. Watch maintenance costs drop.

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For more information, turn to Reader Service Card, Circle No. 313

news of ENGINEERS

Div. Mr. Berry will retain his position as director of development in addition to his new responsibilities.

Edgar W. Engle has joined the technical staff of Fansteel Metallurgical Corp. as assistant to the technical director.

John C. Coonley has been elected president and a member of the board, The Hydraulic Press Manufacturing Co.

Theodore L. Funk has been named assistant chief engineer, McDowell Co., Inc.

Clare B. Carlson has been made manager of the Electrothermic Div., Pittsburgh Lectromelt Furnace Corp.

Dr. F. J. Dunkerley, who for five years has served Rolle Manufacturing Co. as a metallurgical consultant, has been appointed assistant general manager of the company.

Arthur J. Zwanzig has been made assistant to the vice president and general manager, Alloy Precision Castings Co.

Dr. C. Baldwin Sawyer has resigned as president of Brush Laboratories Co. and has agreed to serve as a consultant to Clevite Corp. on special scientific projects.

Dr. Raymond B. Seymour, formerly president, Atlas Mineral Products Co., has been named president, Loven Chemical Co.

Adolf A. Widmann has been appointed vice president in charge of engineering, National Machine Products Co.

General Charles L. Bolté, U.S. Army (Ret.), has become affiliated with ACF Industries, Inc., in the capacity of special assistant to the chairman of the board of directors.

Dr. Walter C. Rueckel has been elected vice president and general manager, Engineering and Construction Div., Koppers Co., Inc.

news of COMPANIES

American Agile Corp. has announced the addition of more than 10,000 sq ft of manufacturing and research area to its present facilities.

American Wheelabrator & Equipment Corp. has changed its corporate name to Wheelabrator Corp.

Bendix Aviation Corp.'s Radio Div. has announced plans to construct a $2,000,000 engineering building devoted to expanded research and de-

DREVER

BELL *Furnaces* **FOR NITRIDING**

Shown is one of the largest nitriding furnace installations in the country furnished by Drever Company and located at National Forge and Ordnance Company, Warren County, Pennsylvania, used for nitriding large diesel engine crankshafts.

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Two (2) 150-KW Furnace Bells
Three (3) Inconel Inner Hoods
Three (3) Bases with Recirculating Fan.

The work chamber is 7'-4" diameter x 13'-6" high, equipped with an alloy inner pedestal for supporting work vertically. Furnace is capable of handling a 21,000 pound charge for nitriding at 1050° F for a normal cycle of 72 hours.

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33

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velopment on commercial and military radar and other communications and navigation devices. The new structure will be located adjacent to the main Radio Div. plant in Baltimore, Md.

Borden Co.'s Chemical Div. has opened a plant in Browntown, Wis., to supply adhesives to the wood industry and wet-strength resins to the paper industry in the midwestern area, and to produce liquid and dry catalysts, label pastes, cements and other chemical specialties.

California Reinforced Plastics Co. has changed its corporate name to Hexcel Products, Inc.

Clevite Corp. has purchased the **Wallace Aviation Corp.** Wallace Aviation will continue to operate under its present name and in its present location.

DeBell & Richardson, Inc., has acquired an additional 20,000 sq ft of working area adjacent to its present location to supplement its laboratory facilities.

The Dow Chemical Co. recently announced that a new plant for the production of polyethylene molding and extrusion materials is now in full commercial production in Freeport, Tex.

Ferro Corp.'s Fiber Glass Div. has made plans to double its facilities in Nashville, Tenn., and, simultaneously, a new fiber glass mat production facility is being built in Southern California.

Ford Motor Co. has completed plans for construction of a metal stamping plant in the Chicago area.

The Glastic Corp. has moved its operation into a new and larger plant at 4321 Glenridge Road, Cleveland 21, Ohio.

Harrisburg Steel Corp. and **Precision Castings Co.** have announced that the two companies will merge. Precision will operate as a division of Harrisburg.

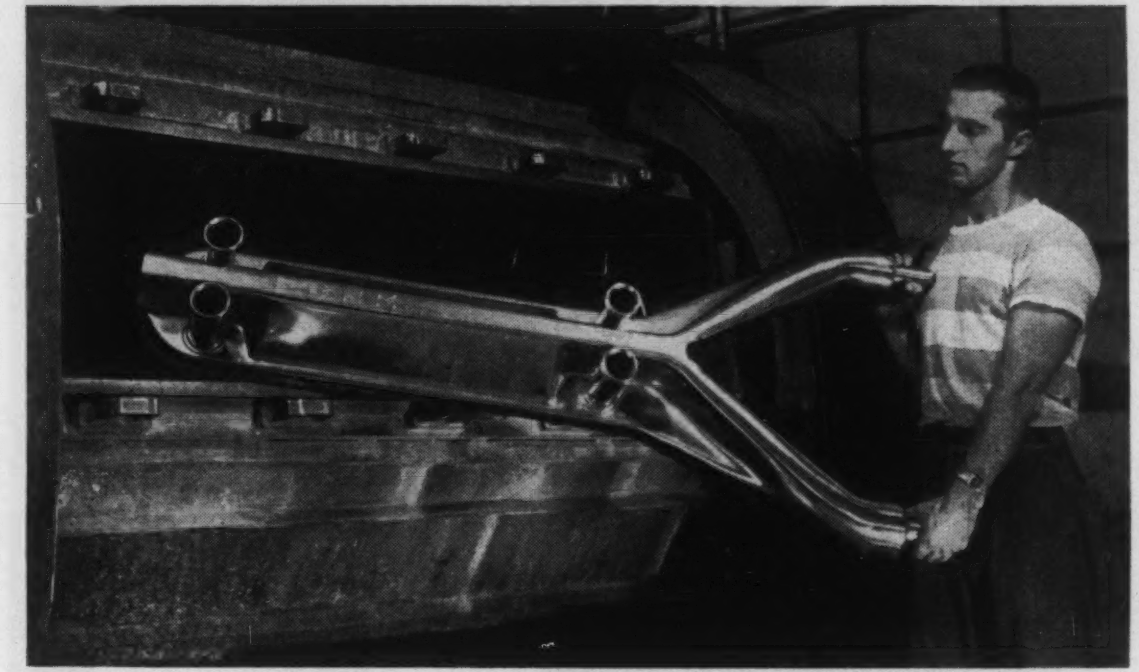
Kester Solder Co. has expanded its plant facilities at Newark, N. J., by more than 50%.

National Starch Products, Inc.'s second polyvinyl resin plant has begun operation in Meredosia, Ill.

Lawrence Process Co., Inc., has completed a 100% expansion in equipment and facilities in the stripping, notching, printing and stitching departments for fibre and plastic welting.

(More News on p. 224)

"40% INCREASE IN LUSTER AFTER USING LORCO COMPOUNDS"



Removing parts from the barrel, after tumbling with Lorco Chips and Compounds.

How an important Pennsylvania manufacturer saved money and solved an unusual barrel-finishing problem.

A large eastern corporation was exploring the possibilities of barrel-finishing stainless steel frames and heat exchanger units.

These frames, measuring 56" x 25", required specially designed fixtures to hold them in the barrel. The first try, according to the manufacturer, was a dismal failure. Numerous types of compounds and chips in varying combinations were experimented with, but none proved satisfactory and costs seemed prohibitive.

Finally, the only way they could do an acceptable job was to scrub the parts by hand with a brush and a soap detergent after tumbling. *And then they learned about LORCO COMPOUNDS!*

Using fused aluminum oxide chips and Lorco Compounds for 20 minutes, a load was washed down and the parts removed. Immediately it was apparent that the luster was greatly improved. Subsequent examination with a Gardner Glossmeter showed an increase in luster of 40% *over anything which had been previously tumbled.* In low costs, Lorco compounds were also winners . . . 39% *under the costs of other compounds.*

If you have a tough barrel-finishing problem, be sure to try Lorco Chips and Compounds. Today they are offering truly amazing answers to the problems of scores of manufacturers . . . for thousands of parts . of all shapes and sizes. Write for detailed information about our free sample processing service and your copy of the new manual, "The Lorco Method of Precision Barrel Finishing."

Lorco

LORD CHEMICAL CORPORATION

2068 SOUTH QUEEN STREET YORK 4, PENNSYLVANIA

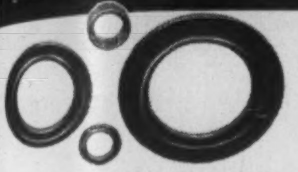
MANUFACTURERS OF BARREL FINISHING COMPOUNDS
TUMBLING BARRELS — MEDIA AND AUXILIARY EQUIPMENT

For more information, turn to Reader Service Card, Circle No. 531

CUT COSTS
with the
Fastest Carburizing
(AND CASE HARDENING)

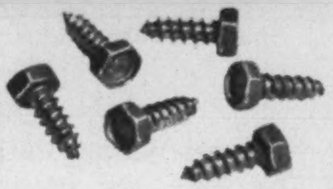
PRODUCTION UP 350% IN

45% Less Floor Space!



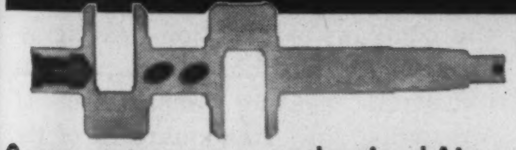
Bearing races and thrust washers are carburized 0.065" case depth in 6 hours at 1700°F in two Ajax salt bath carburizing and tempering lines totaling 6 furnaces, and occupying 45% less space than 21 separate batch type furnaces previously used. Six men handle 3½ times as many races as were previously handled by twelve men.

Costs Cut 60%!



390 pounds of metal body screws per hour are case hardened (0.004" to 0.010") in a single Ajax salt bath furnace no larger than your desk. Bath working dimensions are 36" by 12" by 16". Only 15 to 35 minutes immersion at 1600°F are required — depending on desired case depth. Salt bath carburizing greatly reduced rejects and eliminated a pickling operation.

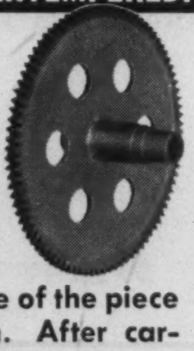
COMBINATION CARBURIZING-MARTEMPERING Saves 35%!



One operator runs a mechanized Ajax line that carburizes and martempers 65 outboard motor crankshafts per hour. Case depth of 0.040" is quickly obtained in a 1760°F bath. Besides an over-all savings of 35%, a copper plating operation and a straightening operation were eliminated. Rejects averaging 4% previously were practically eliminated.

Tractor drive pinions are selectively carburized in this typical Ajax electric salt bath installation. By immersing only the gear in the bath, carburization is obtained where desired and the unheated portions remain unaffected.

Selectively
CARBURIZED AND MARTEMPERED!



Only the teeth and internal spline of this AMS6260 gear are carburized to a 0.035 inch case with a 4½-5 hour immersion. Copper plating of the balance of the piece inhibits carburization. After carburizing and air cooling, gear is reheated and martempered at 500°F for 3½ minutes. Final hardness is Rc 62/63.

Ajax electric salt bath liquid carburizing is the **fastest**, most **economical** method of producing a specified case depth.

Faster Heating . . . Closer Control—A closely controlled case of 0.040" can readily be produced in 2 hours at 1750°F.

Low Costs—*First cost is only 1/2 to 1/5 that of any other production carburizing system!* Much less floor is needed. Maintenance costs are low.

Less Distortion — Temperature uniformity (within 5°F) minimizes distortion . . . assures less finish grinding . . . permits more shallow case depths.

Extreme Flexibility and Simplicity—Several batches may be case hardened simultaneously —each to a different case depth.

Combines with Other Operations — Both carburizing and brazing can be done in one heating of the work. Carburizing can also be combined with martempering.

No "oxygenation" of the case—No pitting and spalling.

Selective Carburizing Simplified—Immerse only the portions of work to be treated, or copper plate the areas that do not require carburizing.

Eliminates Usual Reheating Operation—Work is quenched directly from carburizing bath.

Write for Catalog 116B and documented case histories of carburizing installations.

Send Your sample parts to the Ajax Metallurgical Service Laboratory for processing. No cost or obligation.

AJAX
HULTGREN

electric SALT BATH furnaces

Trademark

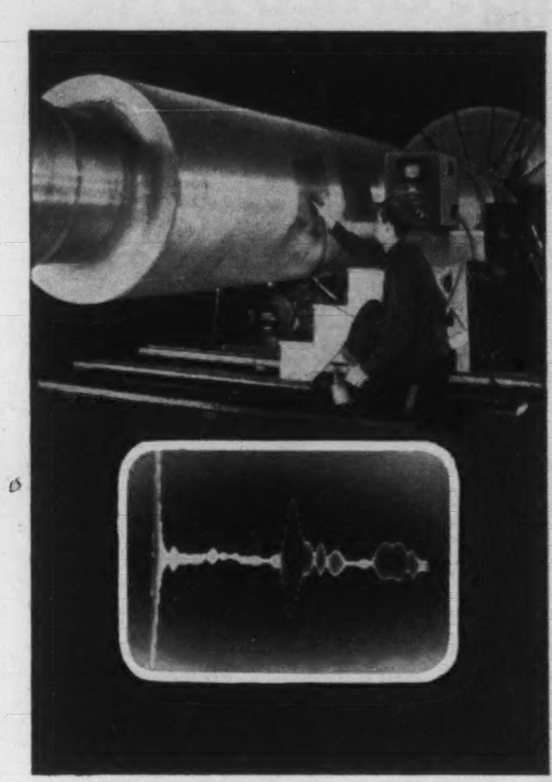
World's largest manufacturer of electric heat-treating furnaces exclusively

AJAX ELECTRIC COMPANY 906 Frankford Ave. **Philadelphia 23, Pa.**

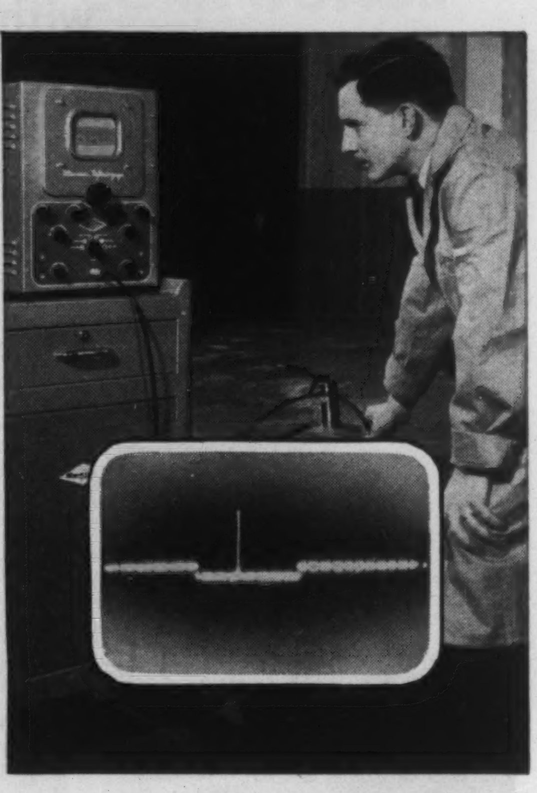
Associated Companies: Ajax Electric Furnace Corp. • Ajax Electrothermic Corp. • Ajax Engineering Corp.

For more information, turn to Reader Service Card, Circle No. 416

TWO SOUND APPROACHES
to new PRODUCTION SAVINGS



SOUND PATTERNS like this on cathode ray tube of Sperry Ultrasonic Testing Reflectoscope saved one company *$1,000,000 in two years.*



SINGLE SHARP SIGNAL for steel-thickness measurement on Sperry Ultrasonic Reflectogage appears against easy-to-read calibrated tape.

through faster, more accurate quality control, better heavy-equipment maintenance

THE SPERRY ULTRASONIC REFLECTOSCOPE

... the portable, nondestructive testing instrument that lets you "see"—quickly, accurately, economically—inside metals and other materials, thus enabling you to:

Cut wasted machine and man hours by locating and evaluating both surface and internal defects in your stock materials before expensive machining.

Eliminate costly production delays by discovering fatigue cracks in your heavy equipment before they lead to breakdown.

Speed and improve inspection of your critical finished parts.

THE SPERRY ULTRASONIC REFLECTOGAGE

... the new, portable measuring and testing instrument that gives sharp, accurate indications of steel thickness ranging from .014 to .400 inches and offers a fast, economical way to:

Measure thickness of steel sheet where only one surface is available.

Check for lack of bond.

Test stock materials for laminar-type defects.

Assure uniform quality while saving time, labor and material in sheet production and processing operations.

SPERRY PRODUCTS, INC.
Leader Since 1928
in Nondestructive Testing

Like to know more? Simply fill out and mail the coupon below. We'll send you free copies of our two new technical bulletins giving full details.

Sperry Products, Inc.
405 Shelter Rock Road, Danbury, Conn.

Please send me a copy of your new Technical Bulletin giving full details on the:

☐ Sperry Ultrasonic REFLECTOSCOPE (Materials to be tested ....)

☐ Sperry Ultrasonic REFLECTOGAGE (Materials to be tested ....)

☐ Have your representative call. ☐ Tell me how to arrange for free showing of 10-minute, 16mm sound-color film explaining theory and application of ultrasonic testing.

MAIL NOW

Name ....

Title ....

Company ....

Street ....

City .... Zone .... State ....

See catalogue 1h-Sp in Sweet's 1955 Plant Engineering File.

For more information, turn to Reader Service Card. Circle No. 482

news of COMPANIES

Nopco Chemical Co. has established a Plastics Div. and has given authority for a million dollar expansion program of its facilities and organization.

Reichhold Chemicals, Inc., recently announced the opening of a new plant in Kansas City, Kans., for the production of Plyophen liquid and powdered phenolic resins.

Rohm & Haas Co. has completed a new and larger building for its plastics Research and Development Laboratory at Bristol, Pa.

St. Regis Paper Co.'s Panelyte Div. has announced a $500,000 expansion program which will increase substantially its injection molding and vacuum forming capacity.

Southwestern Industries has moved to a newly-completed plant at 5880 Centinela Ave., Los Angeles.

Stewart-Warner Corp. has agreed to purchase the entire business and assets of **John W. Hobbs Corp.**

Sylvania Electric Products Inc.'s Parts Div. has made plans to erect a new plastics plant and warehouse in Warren, Pa.

Vanadium-Alloys Steel Co. and **Pittsburgh Tool Steel Wire Co.** have agreed to a merger.

Vitro Corp. of America has purchased a substantial stock interest in **Thieblot Aircraft Co., Inc.**

Westinghouse Electric Corp. has formed an Industrial Heating Div. which will combine the functions of the company's induction heating activities at Baltimore, Md., and the industrial heating department at Meadville, Pa. Headquarters of the new division will be at Meadville, Pa.

Wyman-Gordon Co. has purchased a substantial interest in the **Prex Corp.**

The Mitchell-Bradford Chemical Co. has moved into its new plant at Wampus Lane, Milford, Conn. (In our June issue the company's former address was mistakenly given as the site of the new plant.)

Anaconda Aluminum Co. has formally opened its $65,000,000 primary aluminum plant in Columbia Falls, Mont.

Anaconda Wire & Cable Co. has started production of aluminum wire and cable in a new building at Sycamore, Ill.

Barry Controls Inc. recently announced it has begun a $300,000 expansion of facilities.

(More News on p. 226)

LE ROY MACHINE CO., LE ROY, NEW YORK

COMPARATIVE FINISHING COSTS FOR JET ROTOR COMPRESSOR DISCS

FINISHING METHOD	FINISH TIME	COST PER DISC	QUALITY	DISCS PER YR.	COST PER YR.	PROD. INCR.	COST SAVINGS
FILE AND WIRE BRUSH	18 HRS.	$124.92	VARIED	231	$28,870	—	—
SUPERSHEEN DBF-200 BARREL	4 HRS.	$ 5.68	UNIFORMLY GOOD	1040	$ 5,907	**450%**	**$124,000**

1955
ALMCO
SUPERSHEEN
AWARD WINNER

HOW AIRCRAFT PARTS FIRM SAVED $124,000 WITH ONE SUPERSHEEN BARREL

This Almco SUPERSHEEN fixture-type barrel is paying for itself every week.

Compressor rotor discs for jet aircraft must be finished to rigid Air Force specifications at the Le Roy Machine Co., a New York manufacturer of automotive and aircraft parts. Above you see the final inspection of these parts, just barrel finished. Inspected under powerful magnifying glass, critical break-edges of the discs are right down to A. F. specs.

"Supersheen methods were largely responsible for achieving and maintaining the high quality required for aircraft manufacture," reports R. O. Braaten, Le Roy project engineer. Prior to the installation, the rotor discs were deburred by file and wire brush.

Then an Almco finishing engineer recommended that some sample discs be barrel finished . . .

In Almco's Newark laboratory, it was found that deburring these parts required tough, Supersheen bonded abrasive chips, ⅛ in. steel diagonals and abrasive compound to meet strict A. F. requirements and yet get the fastest possible cutting, grinding and polishing action.

That's how the SUPERSHEEN METHOD cut finishing time from 18 to 4 hours per disc, achieving absolutely uniform finish. Too, production was increased 450 percent, saving $124,000. annually on deburring costs.

Remember, the SUPERSHEEN METHOD is a complete barrel finishing service that begins with an Almco finishing engineer analyzing your specific problem. Then free tests are conducted on your sample parts at the Almco laboratory nearest your plant. The correct media, compounds, barrel rpm, water level and time cycle are determined in order to precision finish those parts; often a complete test can be run in a matter of hours.

Helping you select the correct size barrel or barrels for your operation is the next step. And whenever you need expert help in finishing problems, ALMCO is at your service. For further information and literature, write, Almco, 104 Marshall St., Albert Lea, Minn.

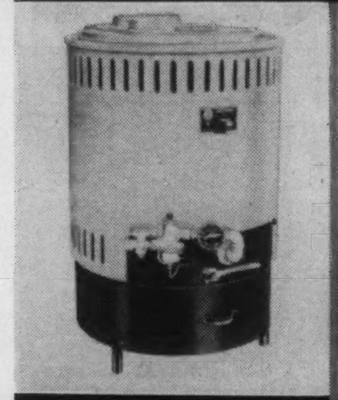
ALMCO
Division of Queen Stove Works, Inc.,
ALBERT LEA, MINN.

SUPERSHEEN METHOD
FOR
SPEED FINISHING

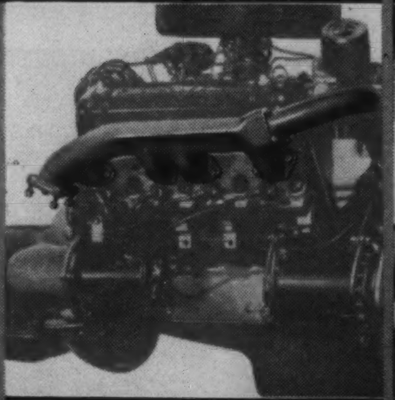
ALBERT LEA • NEWARK • DETROIT
PHILADELPHIA • NEW HAVEN
LOS ANGELES

For more information, turn to Reader Service Card, Circle No. 478

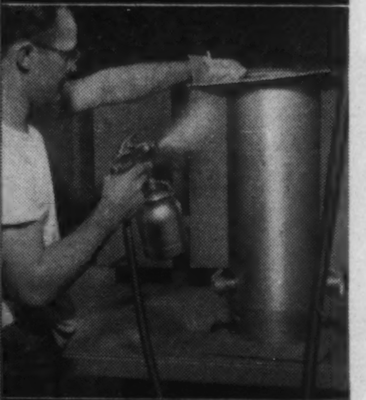
152 Problems in
HEAT RESISTANT FINISHES
solved by Sicon
AMERICA'S FIRST AND FOREMOST SILICONE PROTECTIVE COATINGS



Smart SICON White for INCINERATORS. Protects up to 550°F.



SICON Black For Manifolds. Protects up to 1000°F.



SICON Aluminum for jet engines. Protects up to 1000°F.

Shown above are examples of 152 product finish applications successfully solved by SICON last year after high temperatures had decomposed ordinary finishes. (See partial list below.)

The ease with which SICON can be applied—its remarkable film adhesion and stability under high heat without peeling, blistering, or losing gloss—accounts for its high preference for these products.

SICON can be formulated in smart decorative colors for use in the 550°F. range, and in aluminum or black in the 750-1000°F. range. Check the products below which are similar to yours. Complete technical data will be sent, together with latest brochure of case histories. Fill out and mail today.

New Brochure of Case Examples Now Ready

Sicon
withstands up to
1000°F.
without peeling
or blistering.

EASY TO APPLY
by Brush, Spray
or Dip

MIDLAND
Industrial Finishes Co.
55 East Water Street, Waukegan, Illinois

Please send brochure and data for items checked, on SICON applications.

☐ Air Conditioning
☐ Aircraft Parts
☐ Appliances
☐ Arc Lamps, Spotlights
☐ Automotive Parts
☐ Boilers, Burners
☐ Chemical Equipment
☐ Control Systems
☐ Elect. Control
☐ Elect. Melting Pots
☐ Electronic Equipment
☐ Furnaces
☐ Gas Ranges
☐ Grilles
☐ Hardware
☐ Heaters
☐ Incinerators
☐ Metal Cabinets
☐ Mining Machinery
☐ Motor Bikes
☐ Name Plates
☐ Oil Burners
☐ Packaging Machinery
☐ Pumps
☐ Resistors
☐ Starters, Clutches
☐ Stoves
☐ Surgical Machines
☐ Thermometers
☐ Transformers
☐ Tubing, Steel Welded
☐ Turbo Dryers
☐ X-Ray Equipment

NAME________________

TITLE________________

FIRM________________

ADDRESS________________

CITY, ZONE AND STATE________________

For more information, turn to Reader Service Card, Circle No. 362

news of COMPANIFS

The Electric Service Engineering Co. has been purchased by **H. K. Porter Co., Inc.,** and will be known as the Eseco Div. of Porter.

Gulton Mfg. Corp. has established the Engineered Magnetics Div. at Culver City, Calif., for the development and manufacture of magnetic amplifiers and magnetically regulated power supplies.

Iron Fireman Manufacturing Co. has announced plans to construct a $900,000 manufacturing plant at Ligonier, Ind.

Kaiser Aircraft & Electronics Corp., a wholly-owned subsidiary of Willys Motors, Inc., has acquired the aircraft and electronics businesses formerly conducted by its parent automotive firm.

Key Co. has decided to accept the offer of **ACF Industries, Inc.,** to acquire its property and assets.

Pittsburgh Plate Glass Co. has announced the commencement of construction on its multi-million dollar Glass Research Center near Pittsburgh.

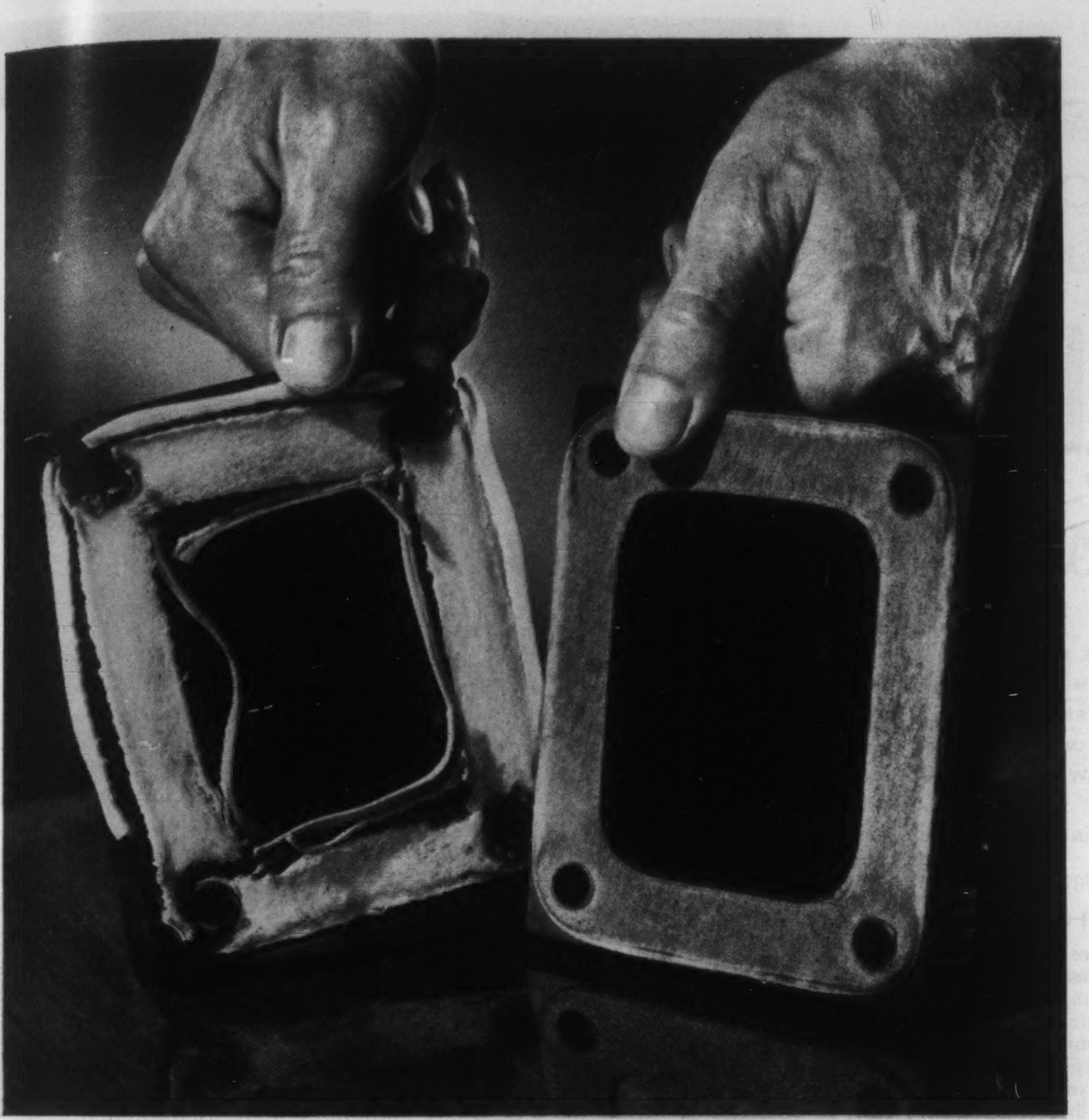
news of SOCIETIES

The Alloy Casting Institute, at its 15th annual meeting, elected Thomas Rutherford, The Midvale Co., as president, and Bradley B. Evans, Empire Steel Castings, Inc., as vice president.

The American Iron and Steel Institute's Board of Directors recently elected the following two vice presidents: W. W. Sebald, president, Armco Steel Corp., and William M. Akin, president, Laclede Steel Co.

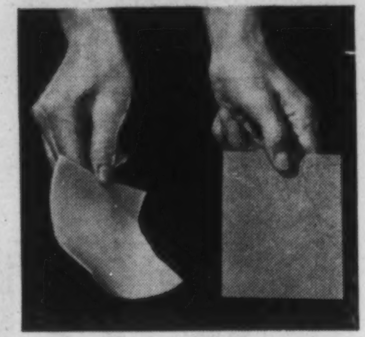
The American Society for Engineering Education has chosen Dr. Maynard M. Boring, consultant on manpower at General Electric Co., as its new president.

The American Society for Testing Materials, at its annual meeting June 26 to July 1, presented several awards for outstanding technical papers and for notable service in specific technical committee fields. The Richard L. Templin Award was given to M. Scott Hunter and William G. Fricke, Jr., assistant chief, Metallography Div., and research metallurgist, respectively, of Alumi-



Cold flow resistance of TEFLON* and reinforced TEFLON (DUROID 5600) was tested at 100° F., under a torque of 35 pounds and a flange pressure of 1,000 p.s.i. After 2 hours the flanges were cooled and the bolts retightened. The flanges were then exposed to the heat for another 2 hours. Results are as pictured. The gasket of TEFLON (left) extruded extensively on all edges and lost all bolt torque. DUROID 5600 did not extrude and retained 15 pounds bolt torque, demonstrating significantly improved resistance to cold flow.

Greater Resistance to Heat Distortion



TEFLON (left) distorted badly when subjected to 720° F. and then cooled. Reinforced TEFLON (DUROID 5600) exposed simultaneously to the same temperature retained flatness, demonstrating greater dimensional stability at high temperatures.

SOME IMPORTANT TEST VALUES

Tensile Strength, MD, psi	2500
Tensile Strength, CMD, psi	1500
Compressibility, 5000 psi, %	8
Thermal Expansion Coefficient per °F., 73-140°F.	2.7×10^{-5}
Heat Distortion Temperature, °F.	
66 psi	500+
264 psi	500+
Deformation under Load, %	
1200 psi	2*
2000 psi	3*
Coefficient of friction against polished steel,	
static	.21
kinetic	.14
Specific Gravity	1.90

*Made up of actual flow and also of compression under load. Data to indicate breakdown between these two portions is being obtained.

ROGERS REINFORCES "TEFLON" TO REDUCE ITS COLD FLOW

Rogers DUROID 5600 is a combination of TEFLON and inert fibers, blended into an homogeneous sheet material. This new material is not a replacement or a substitute for TEFLON, but rather an extension of it. TEFLON has better electrical characteristics and dry lubricating qualities. DUROID 5600, however, has much of TEFLON'S resistance to chemicals, and is greatly superior to TEFLON in resistance to cold flow and heat distortion.

Please write

Dept. M

for Technical Bulletin

*Registered trademark of DuPont Company for its tetrafluoroethylene resin.

ROGERS CORPORATION

ROGERS, CONNECTICUT

Better Parts for Better Products

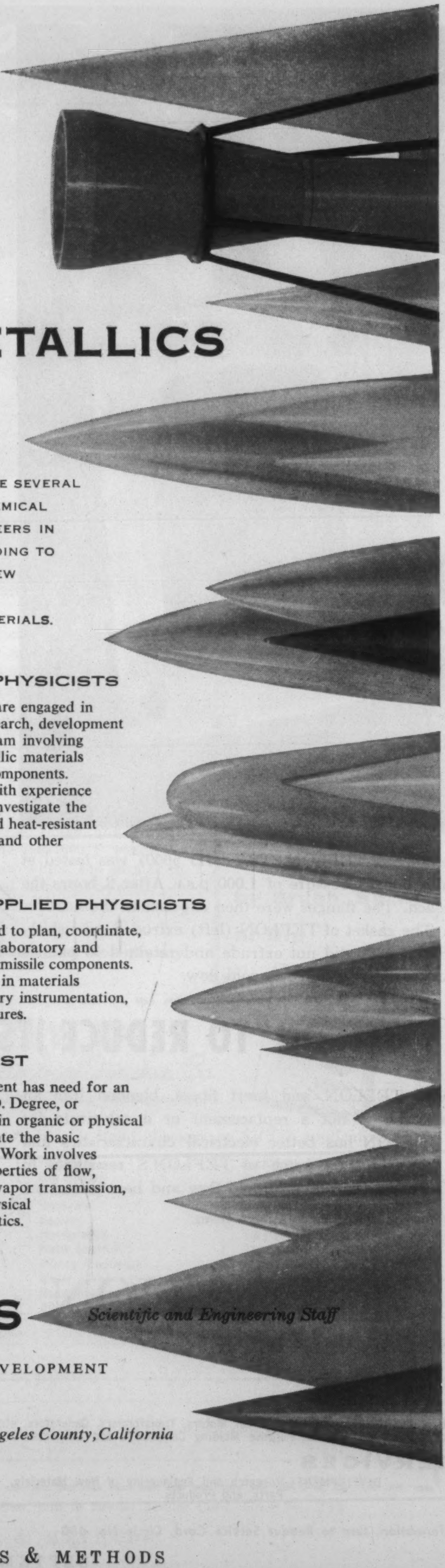
PRODUCTS

DUROIDS—for Gaskets, Filters, Electronic Devices, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc.
ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
PLASTICS—Special Purpose Molding Compounds and Laminates.

SERVICES

FABRICATING—including Combining, Coating, and Embossing.
DEVELOPMENT—Research and Engineering of New Materials, Parts, and Products.

For more information, turn to Reader Service Card, Circle No. 480



Follow the newest field...

NON-METALLICS

HUGHES RESEARCH AND DEVELOPMENT LABORATORIES HAVE SEVERAL OPENINGS FOR CHEMICAL AND OTHER ENGINEERS IN DEVELOPMENT LEADING TO PRODUCTION OF NEW APPLICATIONS FOR NON-METALLIC MATERIALS.

ENGINEERS AND PHYSICISTS

Hughes Laboratories are engaged in a highly advanced research, development and production program involving wide use of non-metallic materials in missile and radar components. The need is for men with experience in these materials to investigate the electrical, physical, and heat-resistant properties of plastics and other non-metallics.

ENGINEERS OR APPLIED PHYSICISTS

These men are required to plan, coordinate, and conduct special laboratory and field test programs on missile components. Experience is required in materials development, laboratory instrumentation, and design of test fixtures.

RESEARCH CHEMIST

The Plastics Department has need for an individual with a Ph.D. Degree, or equivalent experience in organic or physical chemistry, to investigate the basic properties of plastics. Work involves research into the properties of flow, mechanisms of cure, vapor transmission, and electrical and physical characteristics of plastics.

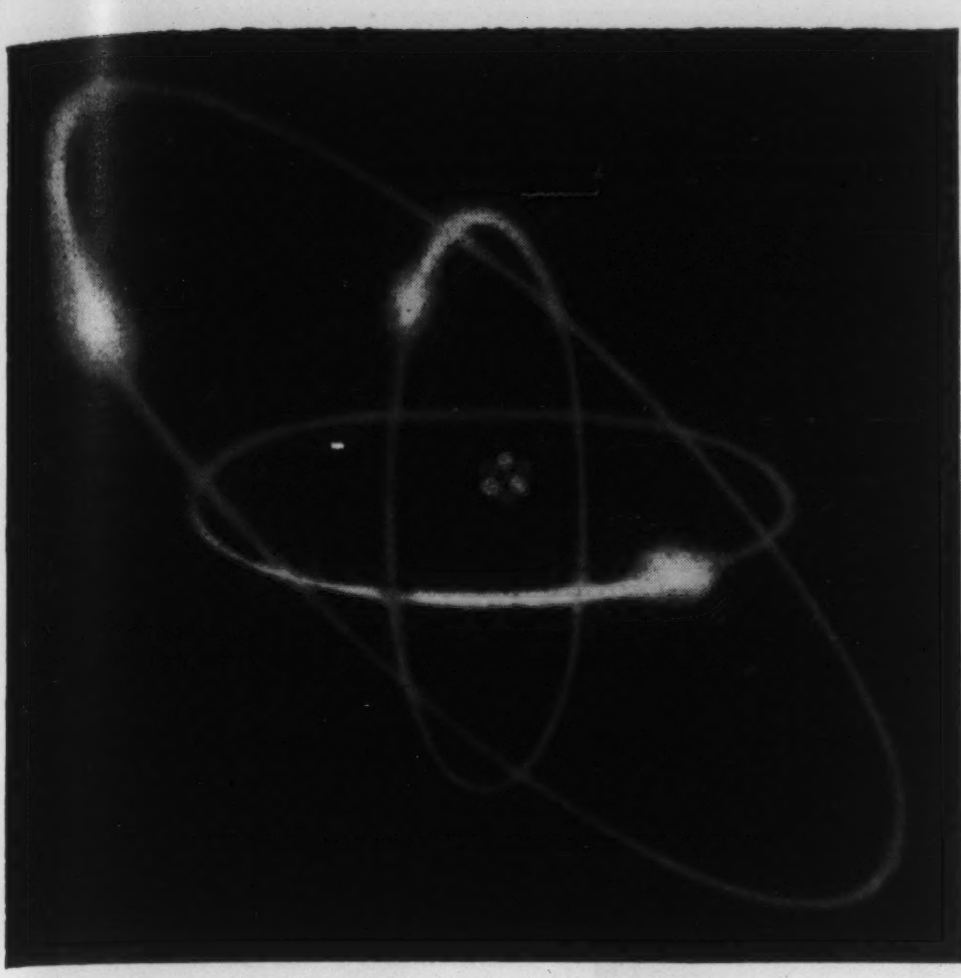
HUGHES *Scientific and Engineering Staff*

RESEARCH & DEVELOPMENT
LABORATORIES

Culver City, Los Angeles County, California

num Research Laboratories, Aluminum Co. of America, for their paper, "The Metallographic Aspects of Fatigue Bahavior." Richard C. Mielenz, head, Petrographic Laboratory, U. S. Bureau of Reclamation, received the Sanford E. Thompson Award for his paper, "Petrographic Examination of Concrete Aggregates." The C. A. Hogentogler Award went to Harold G. Mason and John A. Bishop, U. S. Naval Civil Engineering Research and Evaluation Laboratory, and Philip P. Brown and L. A. Palmer, Bureau of Yards and Docks, Department of the Navy, for their paper, "Piles Subjected to Lateral Thrust." Everett P. Partridge, director, Hall Laboratories, Inc., was presented the Max Hecht Award for outstanding service to ASTM Committee D-19 on Industrial Water in the advancement of its objective—the study of water as an engineering material.

The society, in addition, honored the following leaders in the field of engineering materials with Awards of Merit: Boris J. Barmack, senior engineer, Transmission Engineering Department, Commonwealth Edison Co., in recognition of sustained contributions to the society's work in Committee A-5 on Corrosion of Iron and Steel, particularly on hardware specifications, and for consistent support of other ASTM activities; Christopher Earle Loos, assistant metallurgical engineer, Structural and Plate Bureau, U. S. Steel Corp., in recognition of significant leadership in improving specification requirements for structural steels, and for contributions to Committee A-1 on Steel and its Subcommittee II on Structural Steel; Robert James McKay, (retired) chemical engineer, International Nickel Co., in recognition of intensive interest and contributions through Committee B-8 on Electrodeposited Metallic Coatings, and for support of ASTM corrosion work; William Tudor Pearce, consultant on organic coatings, in recognition of long-time, constructive work in the field of paint, varnish and related products, particularly in Committee D-1 on Paint, Varnish, Lacquer and Related Products, and for support of other ASTM activities; Robert B. Sosman, visiting professor of ceramics, Rutgers University, in recognition of outstanding contributions to ASTM work in refractories, and for sustained leadership in the technical and administrative activi-



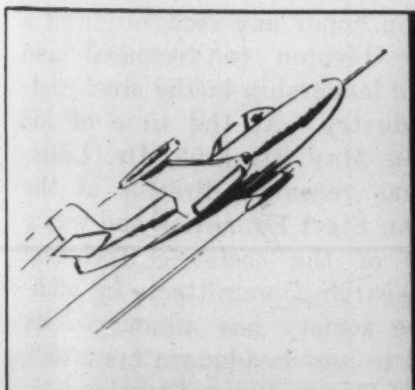
CATALYST OF INDUSTRY

LITHIUM

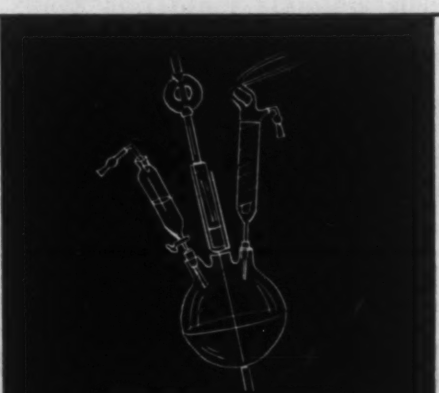
the Miracle Element

cat'a-lyst: chem., the causing or accelerating of a chemical change by the addition of a . . . (catalytic agent) . . .

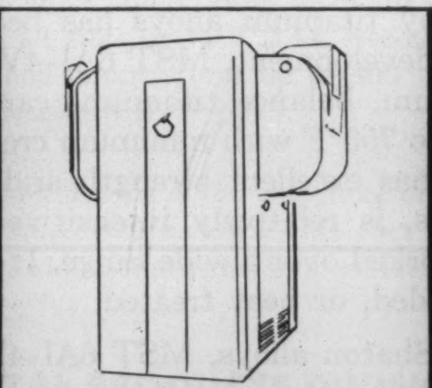
From air conditioning to welding fluxes, Lithium chemicals are the catalysts of industry. Multi-purpose greases, porcelain enamels, organic chemicals, pharmaceuticals, electric storage batteries, heat treating, glazes, electronic ceramics, metallurgy, brazing fluxes—all boast products made better by the addition of Lithium. Architectural porcelain enamels, porcelainized aluminum, low temperature heat treating, cermets, deicing of parked aircraft—these are wholly new fields with an interest in Lithium. Why don't you consider the possibilities Lithium offers for your production process? Investigate the profit potentialities of this wonder metal. We will be glad to discuss it with you.



Brazing Fluxes



Organic Chemistry



Air Conditioning

Multi-Purpose Greases

. . . trends ahead in industrial applications for Lithium

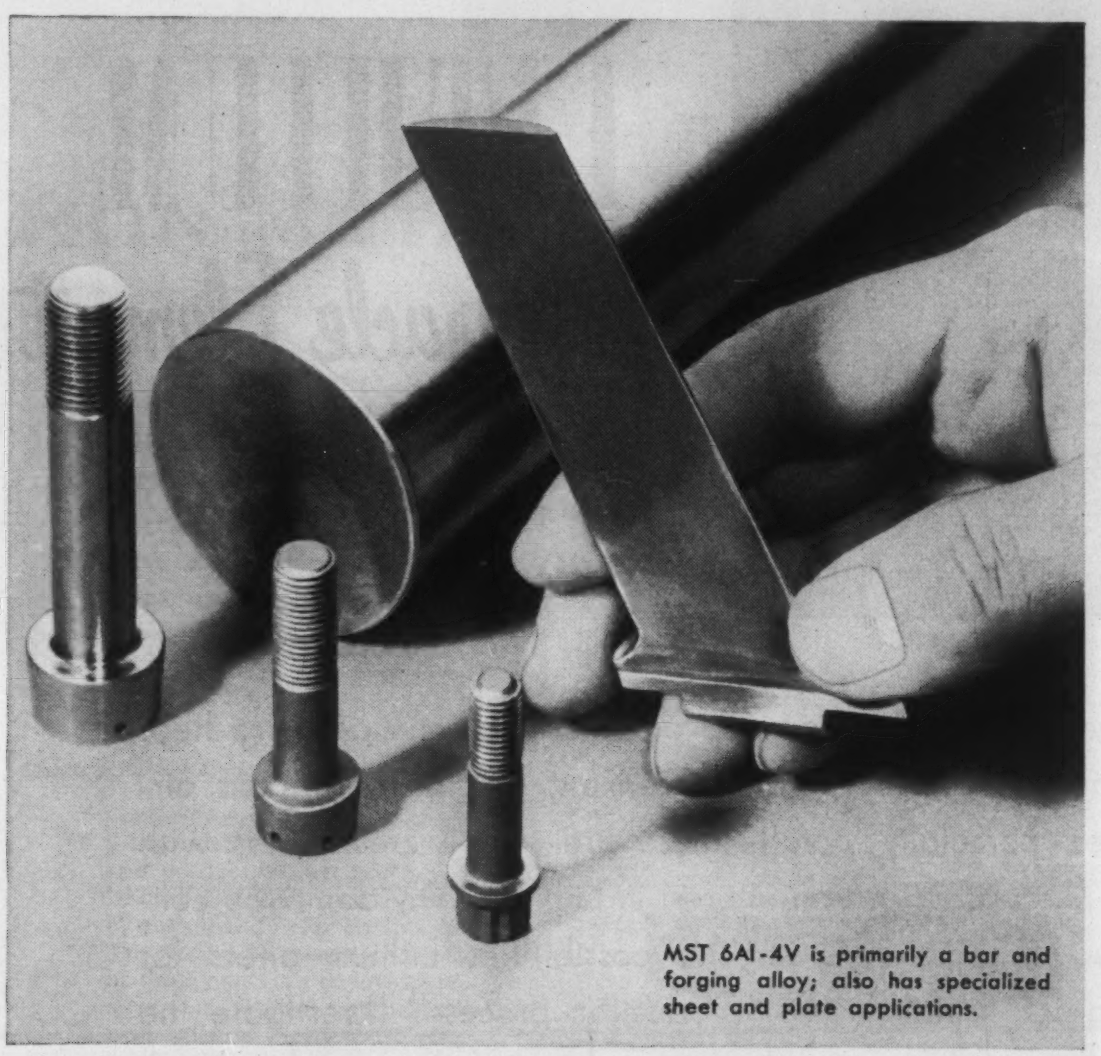
LITHIUM CORPORATION OF AMERICA, INC.
2690 RAND TOWER
MINNEAPOLIS 2, MINN.

MINES: Keystone, Custer, Hill City, South Dakota • Bessemer City, North Carolina • Cat Lake, Manitoba • Amos Area, Quebec • BRANCH SALES OFFICES: New York • Chicago
CHEMICAL PLANTS: St. Louis Park, Minnesota • Bessemer City, North Carolina • RESEARCH LABORATORY: St. Louis Park, Minnesota

For more information, turn to Reader Service Card, Circle No. 392

MALLORY·SHARON reports on

TITANIUM



MST 6Al-4V is primarily a bar and forging alloy; also has specialized sheet and plate applications.

NEW MST ALLOY

"stays put" at high temperatures

● The problem of elevated temperature embrittlement present with many titanium alloys has been overcome with this newest development. MST 6Al-4V (6% aluminum, 4% vanadium, balance titanium) can be used at temperatures up to 750°F with minimum creep or change of properties. It has excellent strength and stability at high temperatures, is relatively insensitive to notches, and can be hot worked over a wide range. It can be readily machined, welded, or heat treated.

Like all Mallory-Sharon alloys, MST 6Al-4V is vacuum double melted, assuring homogeneity and consistent quality. Specify it for consistent, predictable, high temperature performance. A bulletin listing complete data is yours for the asking. Write Mallory-Sharon Titanium Corporation, Dept. G-9, Niles, Ohio.

MALLORY Ti SHARON

For more information, turn to Reader Service Card, Circle No. 381

ties of Committee C-8 on Refractories; William S. Young, section head, Research Div., Atlantic Refining Co., in recognition of notable, constructive service to the society in establishment of ASTM Committees on Absorption Spectroscopy and Mass Spectrometry; and William A. Zinzow, assistant director of development, Bakelite Co., in recognition of sustained support of ASTM technical and administrative work, particularly in Committees D-9 on Electrical Insulating Materials and D-11 on Plastics.

The Drop Forging Assn. has selected Charles W. Stone, Interstate Drop Forge Co., as its president.

The Investment Casting Institute has named Peter W. Schipper, general manager, Investment Casting Div., Howard Foundry, as a director. Also, the Institute has voted to accept an invitation to affiliate with the **National Castings Council.**

The American Nuclear Society has announced the election of Dr. W. H. Zinn as its first president. Dr. Zinn is director of the U. S. Atomic Energy Commission's Argonne National Laboratory.

The Pressed Metal Institute has opened its new headquarters building at 3673 Lee Road, Cleveland 20, Ohio.

The Society of Carbide Engineers has formed a Pittsburgh Chapter with Malcolm Judkins of Firth Sterling, Inc., as chairman.

The Steel Founders' Society of America has established the Gustaf A. Lillieqvist Steel Foundry Facts Award in honor and recognition of a lifetime devoted to technical and scientific leadership in the steel castings industry. At the time of his death on May 31, 1955, Dr. Lillieqvist was research director of the American Steel Foundries and was a member of the society's Technical and Research Committee. In addition, the society has announced its removal to new headquaraters at 606 Terminal Tower Bldg., Cleveland 13, Ohio.

(Meetings & Expositions on p. 232)

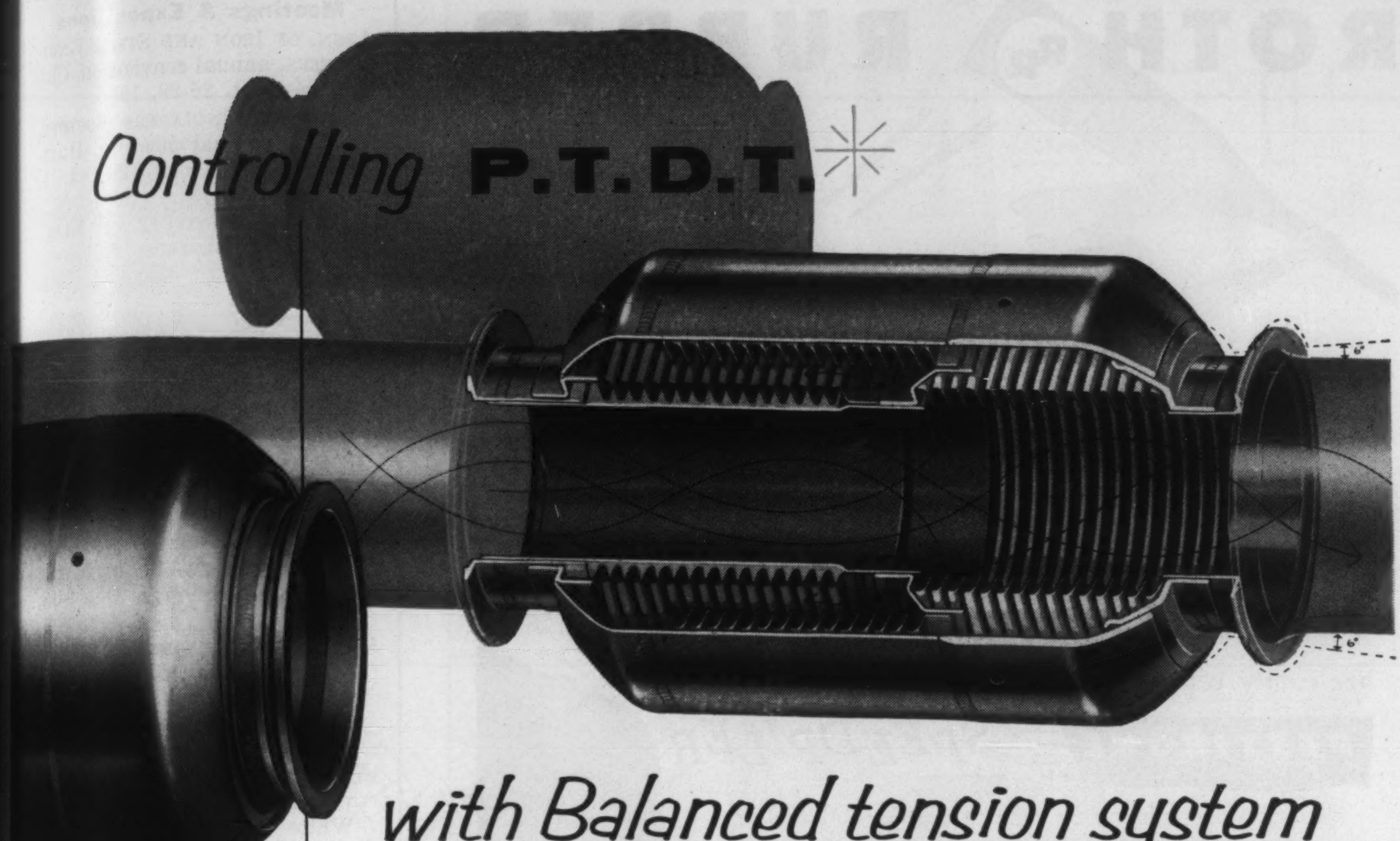
Coming in October

Nodular (Ductile) Irons

by John L. Everhart

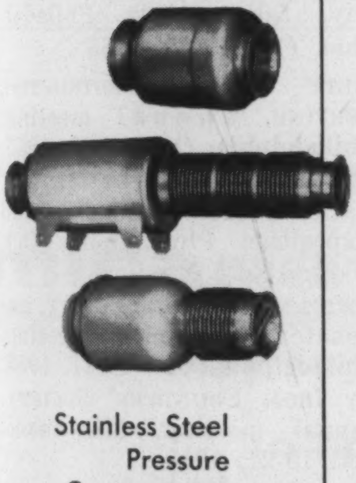
An M & M Manual

Controlling **P.T.D.T.**✳



with Balanced tension system

TO REDUCE WEIGHT



Stainless Steel
Pressure
Compensator
Bellows

Here is the first practical method of balancing the powerful end thrust or "pressure growth" of a pneumatic metal ducting system employing bellows. It is a Pressure Compensator which balances the tension, eliminates the end load and therefore the need for heavy structural bracing. Thus, it saves weight and is particularly applicable for use in bleed air systems in turbo jet and turbo prop powered aircraft.

The primary duct line bellows in this compensator provides for thermal expansion, flexure and misalignment. To offset the tendency of the bellows to straighten out or elongate under pressure, the internal duct pressure is bled off to a series of secondary bellows which create an opposing force to the primary bellows and nullify the end thrust.

Arrowhead builds three types of Pressure Compensators plus tie-rod assemblies and other stainless steel duct components including bellows, and braided assemblies. They are made in all sizes up to 8" I.D. Are capable of handling air pressures of 250 psi or over and temperatures up to 900° F. All spot and seam welding is performed to specification MIL-W-6858.

✳ *Pneumatic Thermal Duct Thrust is the end force or reaction created by a rigid metal duct system employing bellows. This duct thrust is caused by the tendency of the bellows to elongate or straighten out under pneumatic pressure.*

ARROWHEAD METAL PRODUCTS DIVISION ***FORMERLY AIRITE***

ARROWHEAD, leading manufacturer of fiberglass impregnated ducts, sleeves and couplings, now offers stainless steel bellows and duct assembly components to answer all aircraft problems in handling air, gas or fluids. Arrowhead is the first and only manufacturer of ducts who can provide this complete manufacturing service. Field engineers in all localities for consultation.

ARROWHEAD RUBBER COMPANY

Division of National Motor Bearing Company, Inc.

For complete information and engineering data, write Metal Products Division.

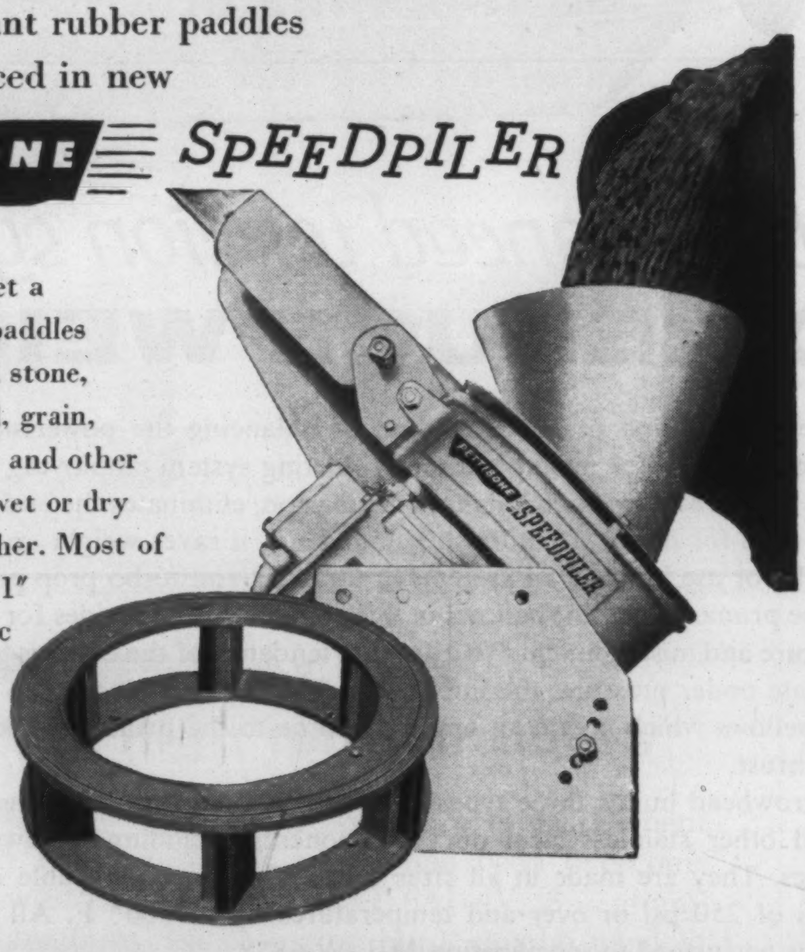
2350 CURRY STREET, LONG BEACH, CALIFORNIA

Pioneer fabricators of silicone rubber; Originators of rubber-fiberglass ducting

For more information, turn to Reader Service Card, Circle No. 488

ROTH RUBBER SPANKS up to 40 TONS AN HOUR!

Abrasion resistant rubber paddles are easily replaced in new PETTIBONE SPEEDPILER



Whirling at 2000 feet a minute, six rubber paddles throw sand, crushed stone, coal, chemicals, feed, grain, salt, sugar, fertilizer and other bulk materials . . . wet or dry . . . 47 feet and farther. Most of this material, up to 1" in size, has a terrific abrasion quality.

Roth Rubber Engineers Solved This Problem

Roth engineers specified and formulated just the right rubber to resist this tremendous abrasive action. Also solved was the problem of fast, easy, inexpensive replacement. Roth engineers can solve *your* rubber problems. There's no obligation for Roth technical assistance. Write us a description of your rubber problem or your rubber requirements. We'll be glad to help.

Engineers and Rubber Buyers!

Write for your free Roth Rubber Sampler. This unusual kit contains actual rubber samples with hardness from 5 to 100 Durometer . . . gives ASTM specs and lists uses for each sample. Sorry, but offer must be limited to engineers and rubber buyers only.

Please ask for Roth Rubber Sampler No. MM2

Custom manufacturers of Industrial Rubber Products since 1923

RR ROTH RUBBER COMPANY

1856 S. 54TH AVENUE • CHICAGO 50

For more information, turn to Reader Service Card, Circle No. 468

Meetings & Expositions

ASSN. OF IRON AND STEEL ENGINEERS, annual convention. Chicago. Sept. 26-29, 1955.

STANDARDS ENGINEERS SOCIETY, fourth annual meeting. Hartford, Conn. Sept. 29-Oct. 1, 1955.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct. 1-5, 1955.

WORLD PLASTICS FAIR AND TRADE EXPOSITION. Los Angeles. Oct. 5-9, 1955.

NATIONAL FOUNDRY ASSN., annual meeting. Chicago. Oct. 6-7, 1955.

PRESSED METAL INSTITUTE, annual convention, Asheville, N.C. Oct. 9-13, 1955.

ELECTROCHEMICAL SOCIETY, fall meeting. Pittsburgh. Oct. 9-13, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aircraft production forum and aircraft engineering display. Los Angeles. Oct. 11-15, 1955.

FOUNDRY EQUIPMENT MANUFACTURERS ASSN., annual meeting. White Sulphur Springs, W. Va. Oct. 13-15, 1955.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div., fall meeting. Philadelphia. Oct. 17-19, 1955.

SOCIETY FOR NONDESTRUCTIVE TESTING, annual meeting. Philadelphia. Oct. 17-20, 1955.

AMERICAN SOCIETY FOR METALS, National Metal Congress and Exposition. Philadelphia. Oct. 17-21, 1955.

AMERICAN WELDING SOCIETY, national fall technical meeting. Philadelphia. Oct. 17-21, 1955.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Milwaukee. Oct. 19-21, 1955.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Oct. 24-25, 1955.

AMERICAN STANDARDS ASSN., annual meeting and national conference on standards. Washington, D. C. Oct. 24-26, 1955.

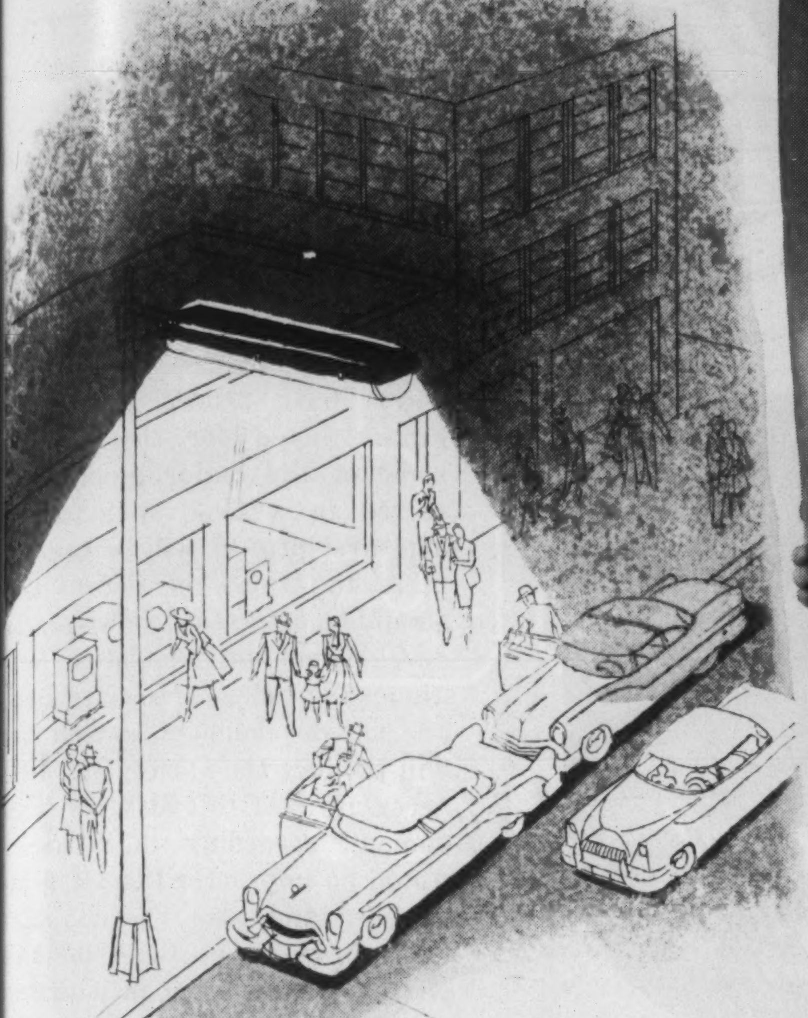
PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Oct. 26-28, 1955.

MAGNESIUM ASSN., annual meeting. New York. Oct. 31-Nov. 1, 1955.

INVESTMENT CASTING INSTITUTE, fall meeting. Detroit. Nov. 1-3, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, Diesel Engine meeting. St. Louis, Mo. Nov. 2-4, 1955.

METALS CASTING CONFERENCE. Lafayette, Ind. Nov. 3-4, 1955.



The practical advantages of this

micarta molding

may suggest a better way

to house your product

This large molding—made of MICARTA Glass-Reinforced Polyester—is currently in wide use as a hood for a fluorescent street lighting fixture. A unique combination of physical properties led to its selection for this tough application. It is immune to any climate—anywhere—won't rust, corrode or warp. It won't dent, and is difficult to scratch. It never needs painting—in fact, permanent color can be incorporated right in the material itself. Maintenance, of course, is nonexistent.

Let us show you how a MICARTA Glass-Reinforced Polyester Molding can be styled to provide a better housing for your product. Write Westinghouse Electric Corporation, MICARTA Division, Hampton, S. C.

J-06610

YOU CAN BE SURE...IF IT'S

Westinghouse

micarta®

GLASS REINFORCED

polyester moldings

For more information, turn to Reader Service Card, Circle No. 426

How do you know you can't do it better with a...

RIVERSIDE

Phosphor Bronze Wire?

Have you ever tried a Riverside Phosphor Bronze Wire for making your springs?

The best way we know of to prove to you that it is a superior product is to have you send for a sample and test it in your own laboratory. Here's what you'll find: the interior of the metal is denser, completely homogeneous, free of voids or imperfections, the surface is smooth and free from microscopic cracks and other imperfections. How does our wire "get that way"? The special method by which it is manufactured.

As a result, Riverside Phosphor Bronze Wires, whether they be flat, round or square, are tough, strong, highly resistant to corrosion, to alternating or repeated stresses which makes them ideal for springs, especially current-carrying springs.

Send today for a sample. Test it and be convinced.

THE RIVERSIDE METAL COMPANY

Division of H. K. Porter Company, Inc.
Riverside, New Jersey
Philadelphia • East Orange, N. J. • Rochester, N. Y.
Hartford • Cleveland • Chicago • Detroit

A DIVISION OF HKP
H. K. PORTER COMPANY, INC.

For more information, turn to Reader Service Card, Circle No. 487

News Digest

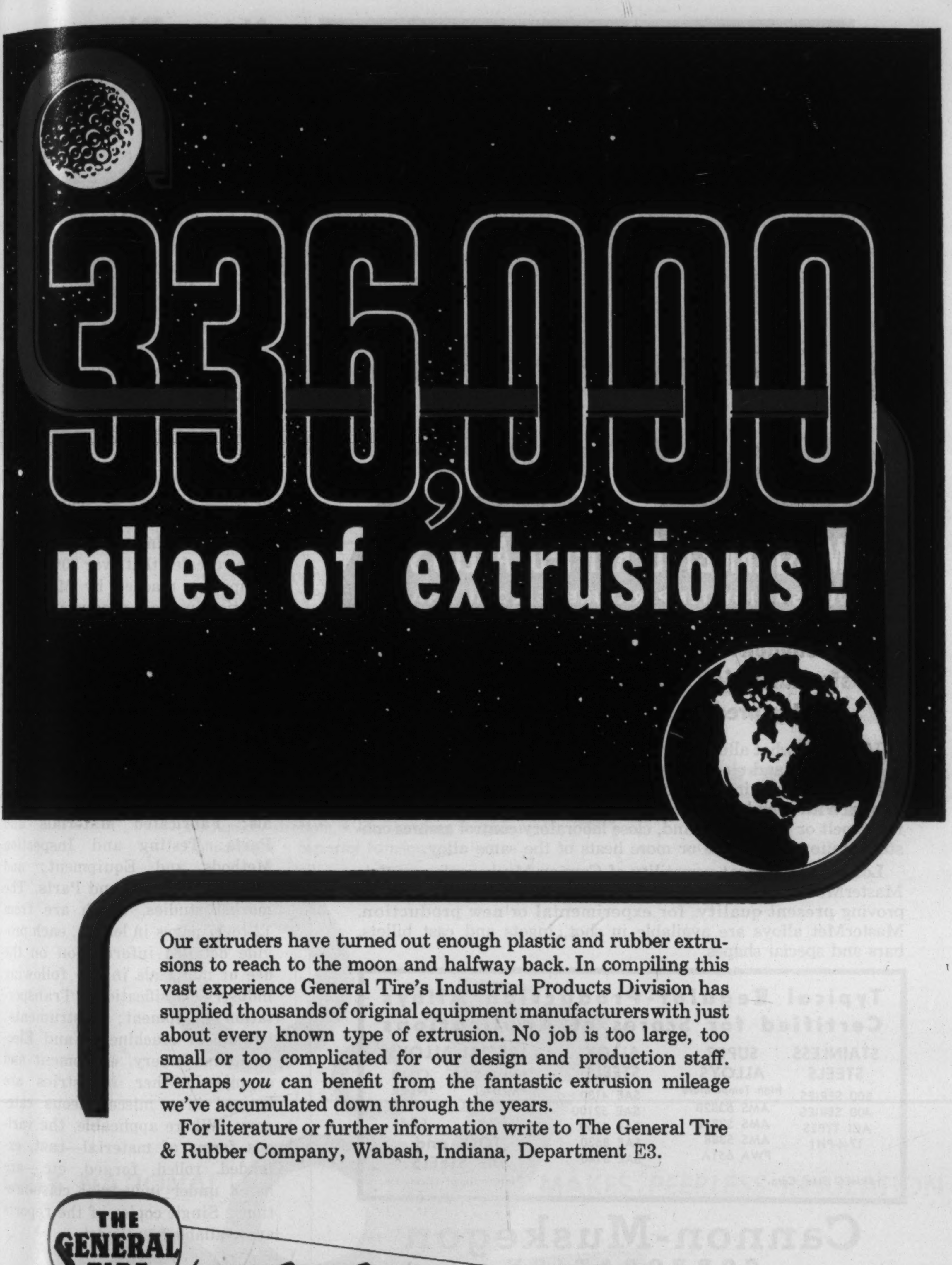
continued from page 14

recommendation now before the ASTM is the *Tentative Recommended Practice for the Resonance Method of Ultrasonic Testing*, which covers all basic types of resonance testing and recommends certain techniques and procedures which have proved satisfactory. Smack listed for the conferees some of the major problems involved in setting up standards. The first project will be to determine the types of defects that should be detected, followed by the development of simulation techniques to produce artificial defects, and the development of tools that will produce the variety of defects necessary. At this stage of development, according to Smack, it would be impractical to set up industry standards. The important thing is to set up bases to which purchasers can refer in setting up standards commensurate with their needs.

M&M Surveys Show Metal Use

"Nothing is made without steel" isn't far wrong, according to the results of the most recent materials market surveys conducted among the subscribers of MATERIALS & METHODS. The M&M survey, which polled a large cross section of the nation's industrial plants, showed that 98% use one or more types of irons and steels in the manufacture of their products. Carbon steels head the list, with 87% of the manufacturers claiming use of it in their products. Surprisingly, the second most widely used steel among the sampled companies is stainless, used by 78% of the manufacturers.

Steel's overwhelming saturation of the manufacturing field runs only a few percentage points above the use of aluminum among industrial plants reached by MATERIALS & METHODS. 88% of product manufacturers report that they use some form of the light metal. The percentage of plants polled which use other nonferrous metals break



Our extruders have turned out enough plastic and rubber extrusions to reach to the moon and halfway back. In compiling this vast experience General Tire's Industrial Products Division has supplied thousands of original equipment manufacturers with just about every known type of extrusion. No job is too large, too small or too complicated for our design and production staff. Perhaps *you* can benefit from the fantastic extrusion mileage we've accumulated down through the years.

For literature or further information write to The General Tire & Rubber Company, Wabash, Indiana, Department E3.

THE GENERAL TIRE
Industrial Products Division
WABASH INDIANA

"From Plans to Products in Plastics and Rubber"

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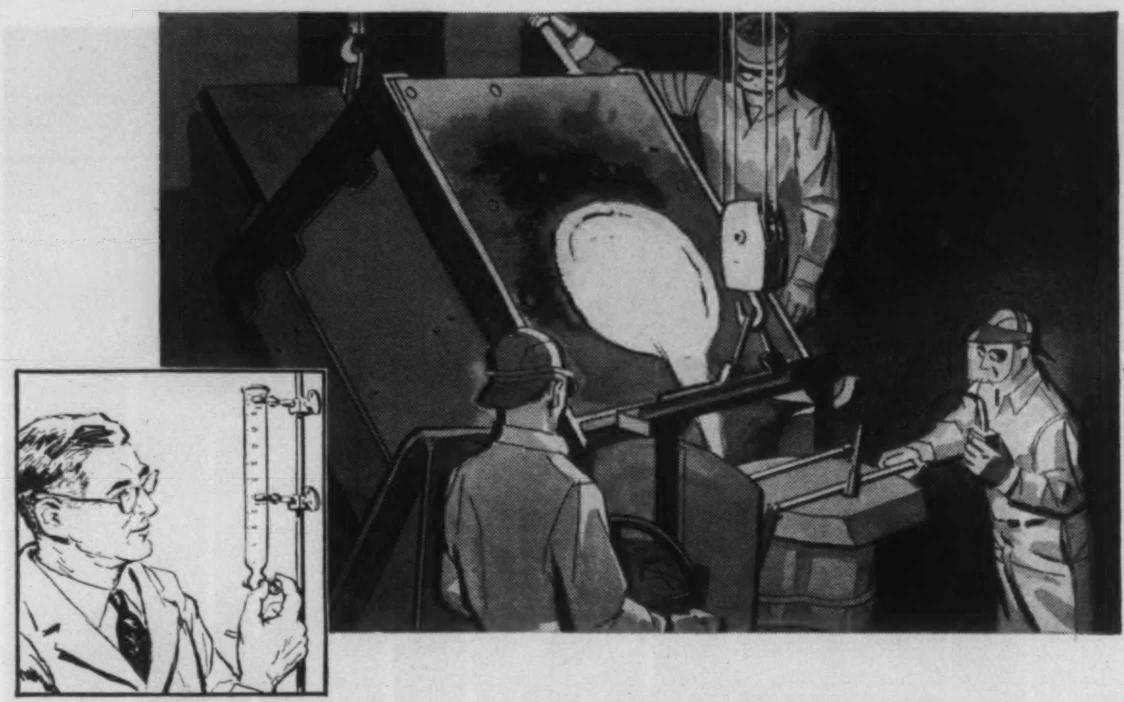


It pays to insist on

MASTERMET CERTIFIED ALLOYS

STAINLESS • HIGH TEMPERATURE • SPECIAL ANALYSIS

Make Cannon-Muskegon your source of custom and standard high alloy metals — and be sure of exactly predictable metallurgical control

NO matter what alloys you use, it pays to have the exact physical, chemical and electrical characteristics you want. That's why the leading firms in your industry insist on MasterMet certified alloys. With each heat, you receive a notarized analysis as a guide for remelt or processing. And, close laboratory control assures constant uniformity to one or more heats of the same alloy.

Look into the great versatility of Cannon-Muskegon's complete MasterMet alloy service — and the opportunity it affords for improving present quality, for experimental or new production. MasterMet alloys are available in shot, ingots and cast billets, bars and special shapes.

Typical Regular-Production Alloys Certified for Scores of Applications

STAINLESS STEELS	SUPER ALLOYS *High Temperature*	ALLOY STEELS	SPECIAL ALLOYS	
300 SERIES	AMS 5382B	SAE 4130	*NI RESIST	CU-NI
400 SERIES	AMS 5385B	SAE 52100	*MONEL	NI-CR
ACI TYPES	AMS 5388	SAE 6150	*INCONEL	NI-FE
17-4-PH†	PWA 651A	SAE 8630	INVAR	CR-FE
		SAE 3140	TOOL and DIE STEELS	

†ARMCO Steel Corp.

*International Nickel Co.

Cannon-Muskegon
CORPORATION

2873 LINCOLN STREET • MUSKEGON, MICHIGAN

Cannon-Muskegon is your only source of MasterMet certified alloys — that's why it pays to have the complete story. Write for NEW catalog today.

MASTERMET
CERTIFIED ALLOYS
FOR INDUSTRY

For more information, turn to Reader Service Card, Circle No. 399

down as follows: brass 75%; copper 67%; bronze 58%; nickel 57%; zinc 28%; tin 27%; magnesium 24%; and lead 22%. Including plants using experimental quantities, 11% of the respondents reported using noble metals, 9% rare metals, 8% titanium, and 2% zirconium.

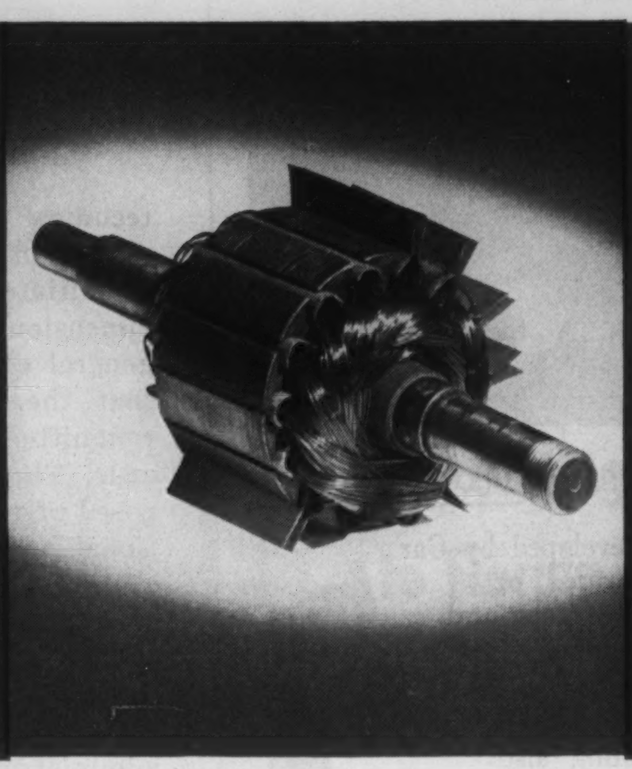
The sampling of industry represented in the statistics above was obtained from a mailing to a random list of 1000 current subscribers of MATERIALS & METHODS. While the sample is not representative of all industry, it does show that a tremendous preponderance of manufacturers use many different basic materials. Last year, a similar sampling of the M&M audience revealed that over 80% of the companies reached by M&M use plastics in their products.

With the publication of the latest market reports, which include detailed breakdowns of materials markets by both industry classification and material type and form, MATERIALS & METHODS now has up-to-date studies on subscriber activities in the following fields: Iron and Steels; Nonferrous Metals; Fabricated Materials and Parts; Testing and Inspection Methods and Equipment; and Plastics Materials and Parts. The market studies, which are from 12 to 17 pages in length, each provide detailed information on the use of materials in the following industry classifications: Transportation equipment; Instruments; Ordnance; Machinery; and Electrical machinery, equipment and supplies. Other industries are lumped in a miscellaneous category. Where applicable, the various forms of material—cast, extruded, rolled, forged, etc.—are listed under industrial classifications. Single copies of the reports are available on request.

Better Standards for Plastics Pipe Urged

Declaring a national need for plastics pipe standards, 35 representatives of manufacturers and consumers of plastics pipe, and

SPECIFY... PEERLESS INSULATION



The ORIGINAL Fish Paper and still the most widely used

Peerless, according to Noah Webster, means "without equal." Peerless Insulation was the *first* fish paper and has been accepted as the standard ever since. Motor and generator manufacturers and makers of electrical equipment find that strong, smooth Peerless Insulation meets their requirements fully. Constant research and rigid quality control assure these essential properties . . .

• High dielectric strength • Bending strength with or against the grain • Excellent flexibility • Ample springiness • Uniform thickness • Unusual mechanical strength • Outstanding toughness • Light weight • Superior forming qualities

Peerless Insulation is available in sheets, rolls and coils in all practical widths and thicknesses from .004" to 1/8".

Write for 16-page General Catalog, Attention Dept. D-9.

NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

ONLY *NATIONAL* MAKES *PEERLESS* INSULATION

Applications for Peerless Insulation include: Duct forms, armature slot insulation, liners, washers, coil insulation, arc shields and formed specialties.

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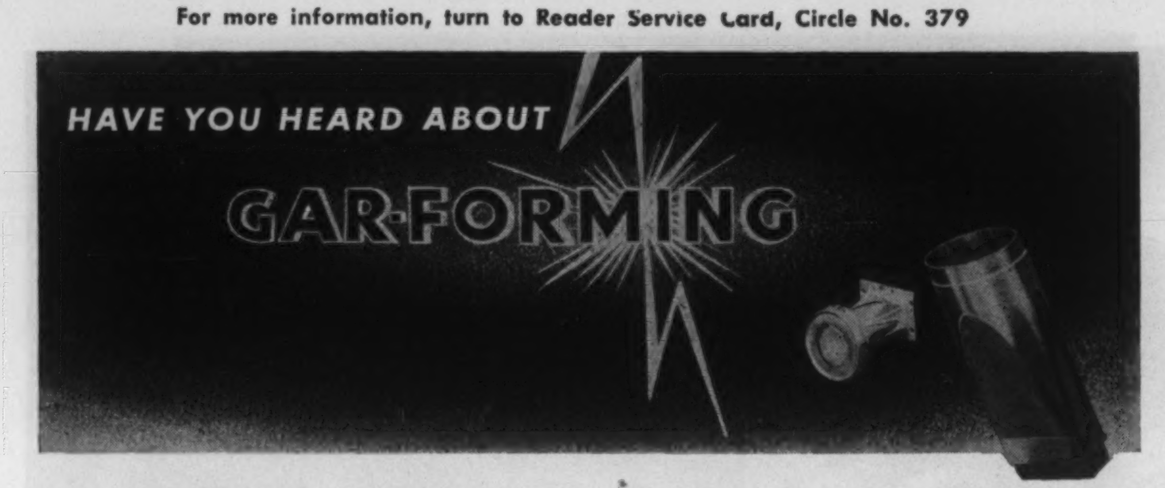
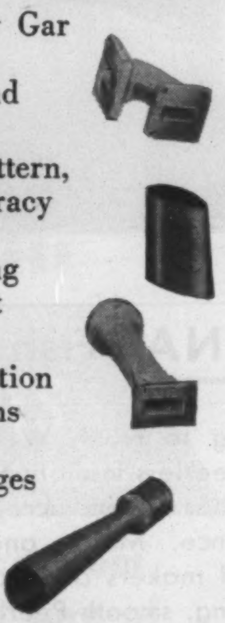
For more information, turn to Reader Service Card, Circle No. 379



for ABSOLUTE ACCURACY in QUANTITY PRODUCTION?

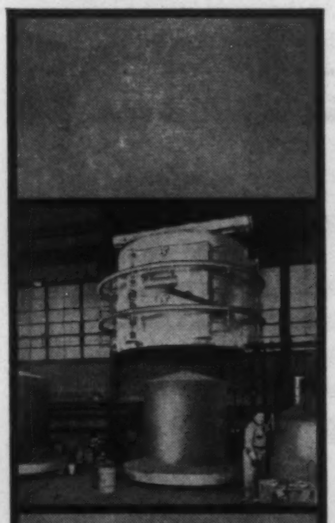


This unique electroforming process was developed by Gar to give you quantity production of full-formed, or sheet parts — to reproduce dimensional accuracy and surface finish to the thickness of a single atom.

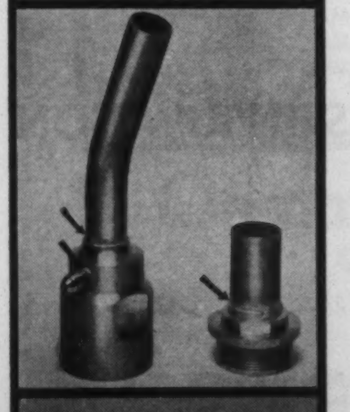
Using electrolytic build-up of the part on a master pattern, this process is uniquely suitable where internal accuracy and surface finish are critical. Gar-forming also permits "growing" of other components in place during part formation, to produce integral assemblies without fabrication distortion.

For production or prototype runs, the wide application possibilities of Gar-forming offer new, practical solutions to design and production problems. Send us your specifications . . . let us show you the specific advantages this unique process can offer you.

GAR PRECISION PARTS, INC.
1 LUDLOW STREET, STAMFORD, CONN.



72-inch diameter hydrogen atmosphere furnace being lowered over furnace bell.



Three brazed joints in jet engine water alcohol valve, utilizing Nicrobraz alloy.

Stainless Joining Problems?

If you must join (or harden, or anneal) stainless steel, then Wall Colmonoy Corporation's Stainless Processing Division can help you. Using Nicrobraz alloy, they produce brazed joints in stainless assemblies that equal the parent metal in tensile strength, at service temperatures of 2000° F. Nicrobraz also has excellent corrosion and oxidation resistance, qualifying it for use in aircraft, pharmaceutical, petroleum, and chemical industries.

Wall Colmonoy maintains three conveniently located plants, equipped with the latest in equipment and skills. Let them handle your experimental and production stainless steel processing and brazing.

Titanium Joining Problems?

The Detroit plant is now brazing and vacuum annealing titanium and its alloys. A new fluxless method has been developed, permitting distortion-free brazing of titanium to titanium, stainless steels, and low alloy steels. Call Detroit for help on titanium joining problems.

Write today for new descriptive brochure.

STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan
PENNSYLVANIA PLANT: Bristol Pike, Morrisville, Pennsylvania
CALIFORNIA PLANT: 1565 Bluff Road, Montebello, California

For more information, turn to Reader Service Card, Circle No. 306

News Digest

technical societies, urged the American Standards Association to initiate a project for uniform dimensions. The group voted at a general conference in New York, that the association organize a committee to develop the standards. The Committee will be composed of representatives of all national organizations having sufficient interest in the results of such a program.

The Society of the Plastics Industry and the American Society of Mechanical Engineers will take administrative leadership in the project as sponsors for the proposed American Standard. The project will establish a new Sectional Committee in the American Standards Association to deal with tolerances, product markings and shop tests for plastics pipe.

The following organizations, attending the meeting, will send technical help to the committee:

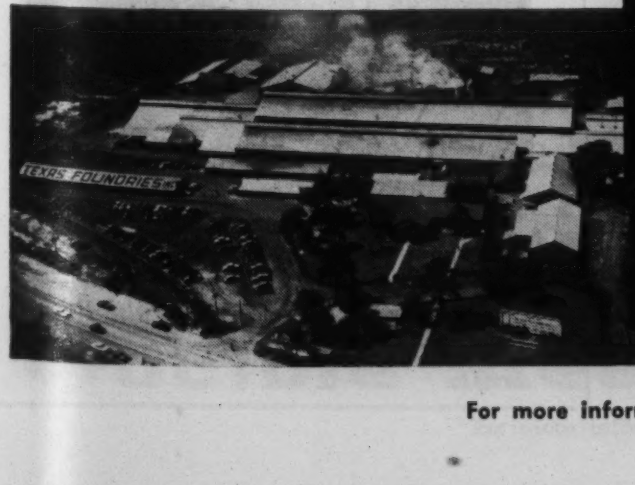
American Gas Association, Inc.
American Institute of Chemical Engineers
American Petroleum Institute
American Society of Heating and Air Conditioning Engineers
American Society of Mechanical Engineers
American Society for Testing Materials
American Society of Refrigerating Engineers
Heating, Piping and Air Conditioning Contractors National Assn.
Manufacturers Standardization Society of the Valve and Fittings Industry
Manufacturing Chemists Association
National Association of Home Builders of the U.S.
National Association of Mutual Casualty Companies
National Electrical Manufacturers Association
Society of Plastic Engineers
Society of Plastics Industry
Synthetic Organic Chemical Manufacturers Association of the U.S.—Thermoplastic Pipe Div.

(More News on p. 240)

the man from Texas Foundries says . . .

Our engineered malleable castings are cutting costs from California to Florida . . . *can we help you?*

Texas Foundries makes consistently uniform malleable castings for a dozen different industries in two dozen states stretching from coast to coast. Our experienced engineers have cut costs on hundreds of metal parts by redesigning for casting in malleable. Case histories are available for your inspection, and your inquiries are invited.



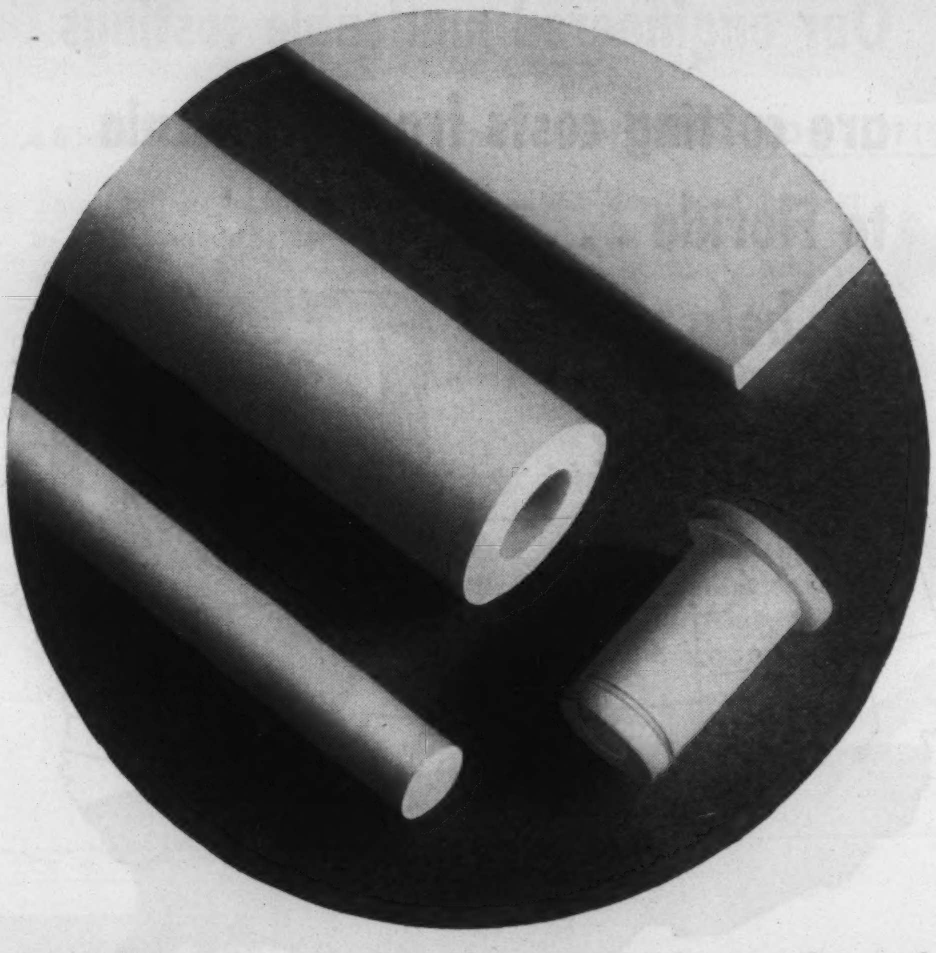
Texas Foundries

Organized for Service

LUFKIN, TEXAS

For more information, turn to Reader Service Card, Circle No. 444

What to look for when using TEFLON® products



All Teflon isn't equal. Apart from its well known chemical inertness, there are these distinct differences that can affect performance and durability:

Non porosity . . . FLUOROFLEX®-T "electrical grade" rods, tubes and sheets are produced with no porosity. Conformance to major electrical and physical properties is *certified.** This assures you reliable operation in even the most critical low loss applications.

Dimensional Stability . . . Increased resistance to elongation is offered you by "mechanical grade" FLUOROFLEX-T . . . which is now available in extruded rods and tubes

Machinability . . . Stress relieving of all FLUOROFLEX-T products means uniform parts, easier machining, and fewer rejects.

Product Quality . . . Available in rods, sheets and tubes, in mechanical parts to your specification, in R-3800 hose assemblies, all FLUOROFLEX-T products have this in common—fabrication under a quality control system approved by the USAF under MIL-Q-5923.

Send for details and for quotations on your needs.

*Copies of test reports on file available on request.

®Fluoroflex is a Resistoflex registered trade mark for products from fluorocarbon resins. Teflon is the DuPont registered trade mark for its tetrafluoroethylene resin.

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For more information, turn to Reader Service Card, Circle No. 349

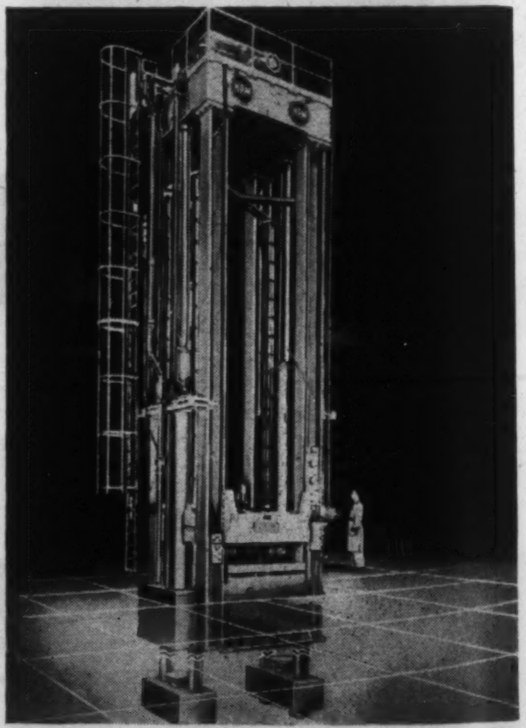
News Digest

Fusion Power Under Discussion

The first public discussion in the U.S. of the control of thermonuclear energy for power generation will take place at the National Industrial Conference Board's 4th Annual Conference to be held in New York on Oct. 26, 27, and 28 at the Waldorf-Astoria Hotel. Hans Thirring, director of the Institute of Theoretical Physics, Vienna, will be one of the principal speakers at the session on nonweapons potentials of thermonuclear energy.

Despite ironclad security restrictions on the mere mention of thermonuclear fusion as a source of power, rumors have been flying in the press for the last few months that practical systems are under development. At least three United States Government sponsored projects for studying thermonuclear power are under way, but no word on progress is available.

Thermonuclear power—the fusion of hydrogen into helium with release of huge amounts of energy—has some great advantages over the production of power from nu-



***Lots of daylight**—27 ft of it—is the outstanding feature of this 17-ft stroke press for reinforced plastics molding built by the Hydraulic Press Manufacturing Co. for Zenith Aircraft.*

right in tune

...and REX is the standard by which all other high speed steels are compared

A tuning fork sounds the *standard pitch* to which musical instruments are compared. There's a recognized standard for high speed steels, too — Crucible REX®.

But don't take our word for it. Try REX in your own shop. Compare its structure, finish, hardenability, carbide distribution and general uniformity. Measure the *extra performance* you get. You'll see for yourself why no other tool steel outperforms REX . . . why it's the *standard for comparison* wherever high speed steels are used.

Next time you buy tool steels, be sure of top performance — specify REX. Remember, it's made only by Crucible — and is available from local warehouse stocks, or by prompt mill delivery. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 470

For more information, turn to Reader Service Card, Circle No. 501

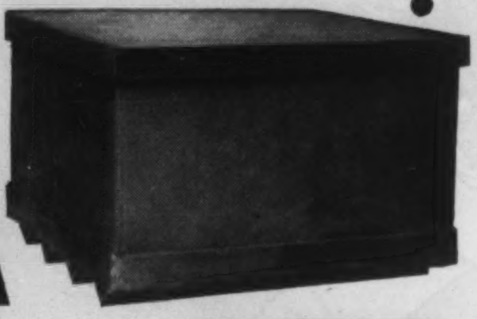
Stanwood CARBURIZING BOXES ARE BUILT FOR MAXIMUM SERVICE HOURS!

Snug Fitting Cover

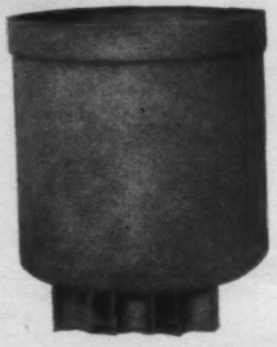
No Welds at Corners

Bottom has Reinforcing Flange

Easy-slide Skid Rails Strengthen Bottom



PLUS FEATURES throughout that insure maximum hours of service. Rolled plate sides cut weight, add room. Corners formed —not welded—all welds gas tight. Even expansion and contraction in all planes. High heat and corrosion resistance. Also square and round carburizing boxes. Stanwoods are Number 1 for service.



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News Digest

clear fission reactions. However, fusion is thought to operate only at such high temperatures, pressures and energy levels that the containment and control of the reaction is more difficult by many magnitudes than the control of the fission of the heavier elements. The advantages of fusion power are an unlimited fuel supply, greater power potential, and fewer and less dangerous reaction products. The "ash" from a pure thermonuclear reaction is believed to consist only of tritium and helium, neither of which pose disposal problems. On the other hand, the ash from a nuclear fission reaction consists of many highly radioactive isotopes, deathly poisonous, with long half-lives. Disposal costs may be as high as original fuel cost.

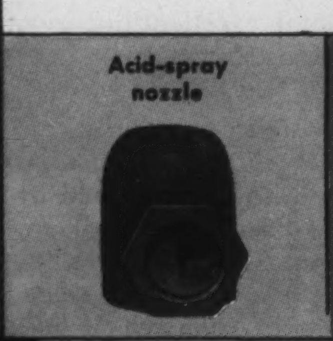
The difficulties facing the developers of thermonuclear reactors are evident from the nature of the thermonuclear reaction when compared to the fission reaction. Fission begins spontaneously when a certain amount of fuel, such as plutonium, Uranium 235, or 233 is brought together under suitable moderating conditions. The reaction is relatively independent of ambient temperature. The fusion reaction, on the other hand, depends upon great concentrations of energy to trigger the chain reaction of hydrogen with hydrogen. Once started, the fusion reaction is self-sustaining and develops temperatures comparable to those in the sun, but it cannot run cool like the familiar uranium pile.

There are absolutely no materials in existence capable of withstanding the direct heat of thermonuclear fission. Materials would not only melt, they would vaporize almost instantly. Presuming that the problem of starting the fusion reaction could be solved by electrical means, such as high energy electron radiation or some sort of super-arc, the violent reaction would have to be sustained in mid air, or gas, while it was fueled by small increments of fuel, which would probably have to be delivered by some sort of particle accel-

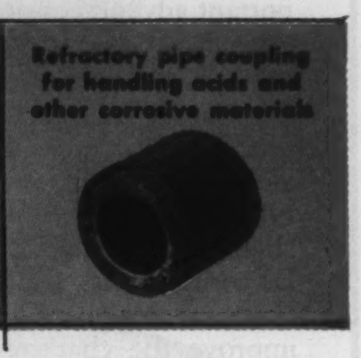
NEW
SUPER REFRACTORY has METAL-LIKE PROPERTIES up to 3000° F

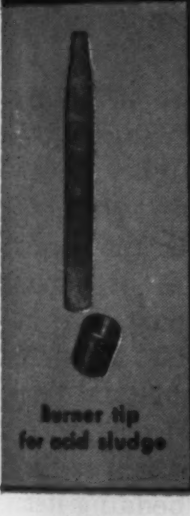
Rocket motor vane operating at 4000°F

3-part sinker assembly for aluminizing steel wire


Acid-spray nozzle

Nut and bolt for high temperature corrosive conditions will mate with metal parts


Refractory pipe coupling for handling acids and other corrosive materials


Burner tip for acid sludge

Burner for use in ceramic kiln at 3200°F

The refractory parts you see above are made of REFRAX® silicon-nitride-bonded silicon carbide. CARBORUNDUM has developed it to fill the need for a material that can be formed into intricate parts with metal-like properties for use at temperatures far above the melting points of the most expensive alloys.

Prices are practical. Since REFRAX parts are supplied in ready-to-use shapes, they are usually far less expensive than high-temperature alloys. In one case, REFRAX brazing fixtures cost only 1/15 as much as the alloy they replaced and gave better than 150 trips without deformation whereas the alloy fixtures needed frequent straightening and refinishing.

Here are some facts and figures that show how well REFRAX materials can answer the special requirements of complicated parts for low to high-temperature service:

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These materials can be produced in intricate shapes to accuracies of ± 0.005 inch per inch, with or without external or internal threads. Surface finish resembles that of a cast metal part. *Unlike many metals, REFRAX shapes show little or no warpage after repeated heating and cooling cycles.*

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At 2450°F, REFRAX refractories have a modulus of rupture of 5600 psi. Even the best heat-resistant alloy melts below this temperature.

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The heat conductivity of REFRAX materials approaches that of chrome-nickel steels.

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The new refractory is inert to most acids at temperatures that range from moderate to extreme. It also stands up against molten slags and molten synthetic mica. Even molten aluminum leaves REFRAX shapes unharmed.

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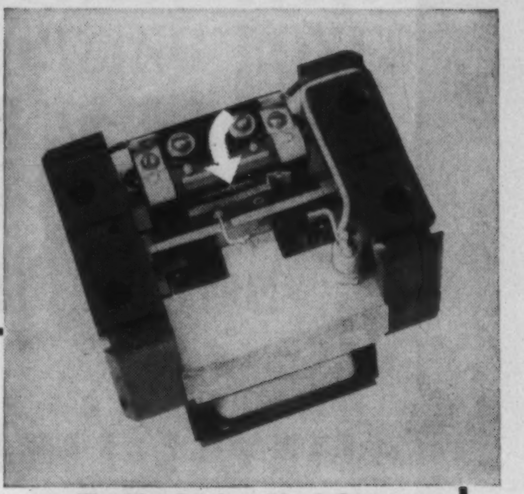
NEY'S small parts play a BIG part in precision instruments



The Ney Precious Metal Contact (indicated by arrow) is an important part of this Genisco Accelerometer.

Genisco Accelerometers are used in the guidance systems of missiles now in large-scale production. They are rugged, potentiometer-type instruments chosen for their reliability and precise performance. For the double-contact wiper of the potentiometer, Genisco selected Ney's Precious Metal Alloy Paliney #7* because it provides the important advantages of holding noise at a minimum, excellent linearity, long life and satisfactory performance in temperatures from —65° F. to +200° F.

Ney Precious Metal Alloys have high resistance to tarnish, are unaffected by most industrial corrosive atmospheres, and have ideal electrical characteristics. These precious metal alloys, developed by Ney especially for precision instruments, have been fabricated into slip rings, wipers, contacts, brushes, commutator segments and similar components. Call the Ney Engineering Department for the selection and design of the right Ney Precious Metal Alloy which will improve the characteristics and prolong the life of *your* precision instruments.

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News Digest

erators which were not affected by the intense heat and radiation from the reaction.

Whether or not the ultimate thermonuclear reactors operate on continuous or intermittent fueling, the problems of heat transfer, containment, control and safety are all much greater than those encountered in fission reactors. Thermonuclear power is undoubtedly farther away from practical application than fission power was at the first explosion of the atomic bomb, but the possibility remains that thermonuclear fusion may be the ultimate power source of the future.

Foam Rubber Prices Rise

Foam rubber prices increased 5 to 10% on Monday, Aug. 8, The Firestone Tire & Rubber Co. announced. The reason given for the price increase is the virtual doubling of the price of natural rubber during the past year according to P. P. Crisp, President of The Firestone Industrial Products Co.

The price increase will be 10% on all furniture and bedding items and pillows, which are made primarily from natural latex. On all sheet stock and foam rubber slabs, which use larger proportions of lower-cost synthetic rubber, the price increase will be 5%.

According to Mr. Crisp, using mattresses as an example, the cost of latex going into the average double size mattress has increased $9.00 during the past year. Only $6.00 of this cost increase will have been passed along to mattress manufacturers.

In explanation of his company's absorption of part of this cost increase, Mr. Crisp said, "We feel a very definite responsibility to those furniture and bedding manufacturers who have been introducing Foamex throughout the nation."

Mr. Crisp pointed out that major expansion programs now under

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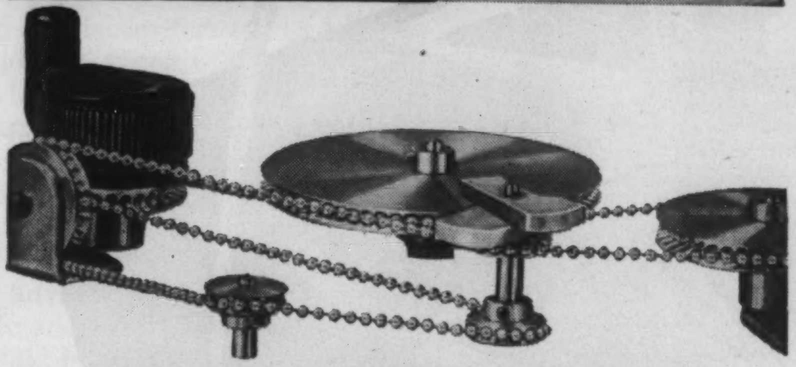

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way to increase the supply of synthetic rubber should help to stabilize the price of natural latex within the next few months. Natural rubber today is selling for about 46 cents per lb, against 23 cents per lb for synthetic rubber.

Electroplaters Develop New Tests

Conferees at the American Electroplater's Society's annual meeting heard welcome news of progress in the development of accelerated tests for atmospheric corrosion. One of the Society's most important research goals, the accelerated corrosion test development program, is expected to lead to an improved research tool for evaluating plating systems and materials. In a report presented by W. L. Pinner of Houdaille-Hershey, the Society was told that the tests now under active consideration include acetic acid-modified salt spray; a road splash test; a paste modification of the road splash test; a British test which includes sulfur dioxide in the corrosive test bath; and a carbon-dioxide and water test. At present, there is no fully adequate accelerated test for atmospheric corrosion, particularly the type that occurs in industrial atmospheres. The object of the AES project is to develop such a test; one that will accurately duplicate actual atmospheric corrosion experience, but on an accelerated time scale. The test must provide data that is reproducible within practical and economic limitations, and of course, give results that correlate with actual service experience. If such a test can be developed, new plating systems can be evaluated and accepted or rejected forthwith. Now, with the exception of salt spray test results which do not represent corrosion resistance to industrial atmospheres, there is only one way to evaluate the performance of plate in industrial atmosphere, and that is to expose it for months and years. Thus a new plating tech-

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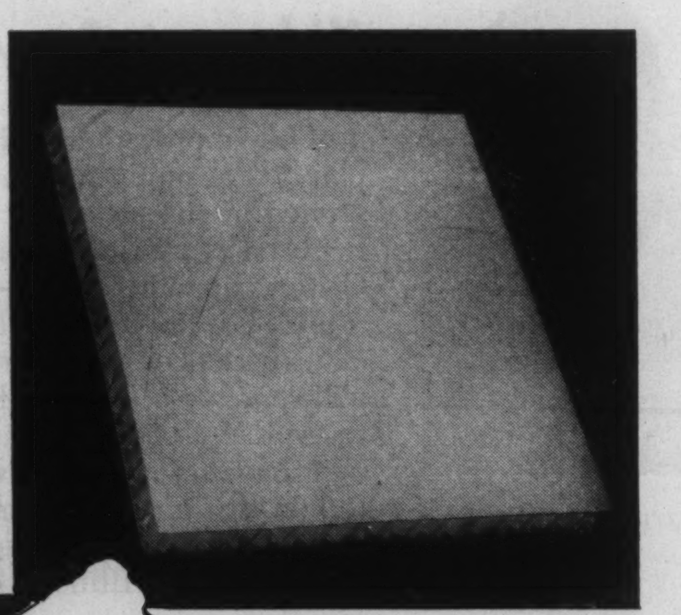
THE IMPERISHABLE METAL

***The successful wedding of glass and aluminum* has been made possible by the recent development of porcelain enamels containing from 30% to 50% lead. Heretofore, neither the materials, the processes, nor the furnaces used for the enameling of iron and steel were suitable for the enameling of aluminum because of the high temperatures involved. For example, even the least refractory of the non-leaded ferro enamels fire at 1500°F — a temperature which is above the melting point of aluminum.**

Lead, one of the oldest and most widely used ingredients in ceramic products, has a melting point of only 621°F — as compared to 1220°F for aluminum. In the form of oxides, such as red lead or litharge, and combined with silica, it makes possible the production of glass coatings in almost any desired color, highly resistant to both acids and alkalis, which can be fired at a temperature of 970°F to 1000°F, which is well below the softening range of aluminum. In addition, lead is relatively abundant and low in cost. As a result, porcelain enameled aluminum provides industry with a material of construction which effectively combines the surface hardness, durability and chemical resistance of leaded glass with the light weight, workability and strength of aluminum.



Section of panel made of impregnated paper core laminated with .051" sheet aluminum, coated on the outside faces with 3 mils of lead-bearing porcelain enamel. The finish is an integral part of the base metal and the rigidity of the aluminum stock is actually increased by it. Since the glass coating itself is very, very thin, it is flexible to a degree not normally associated with glass in the usual sense.

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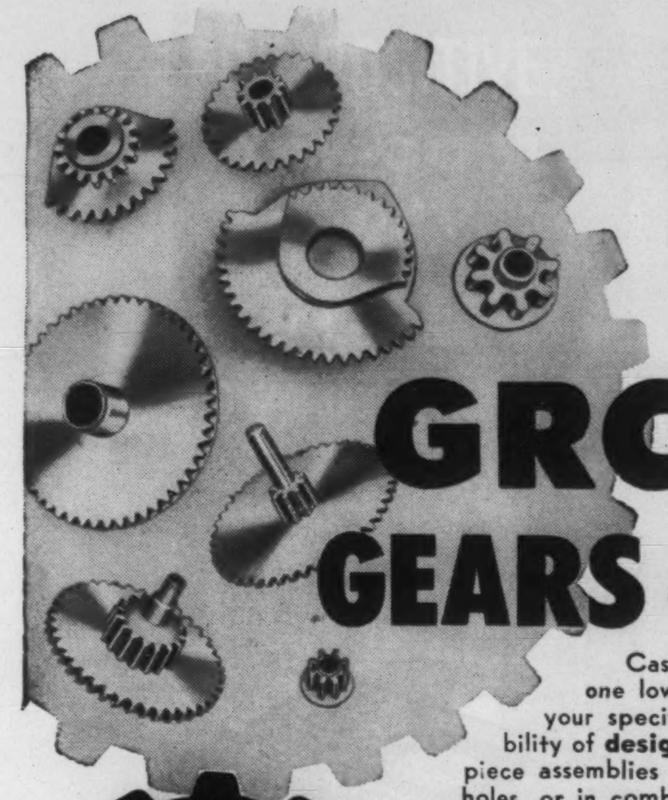

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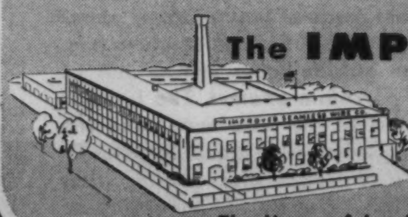

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News Digest

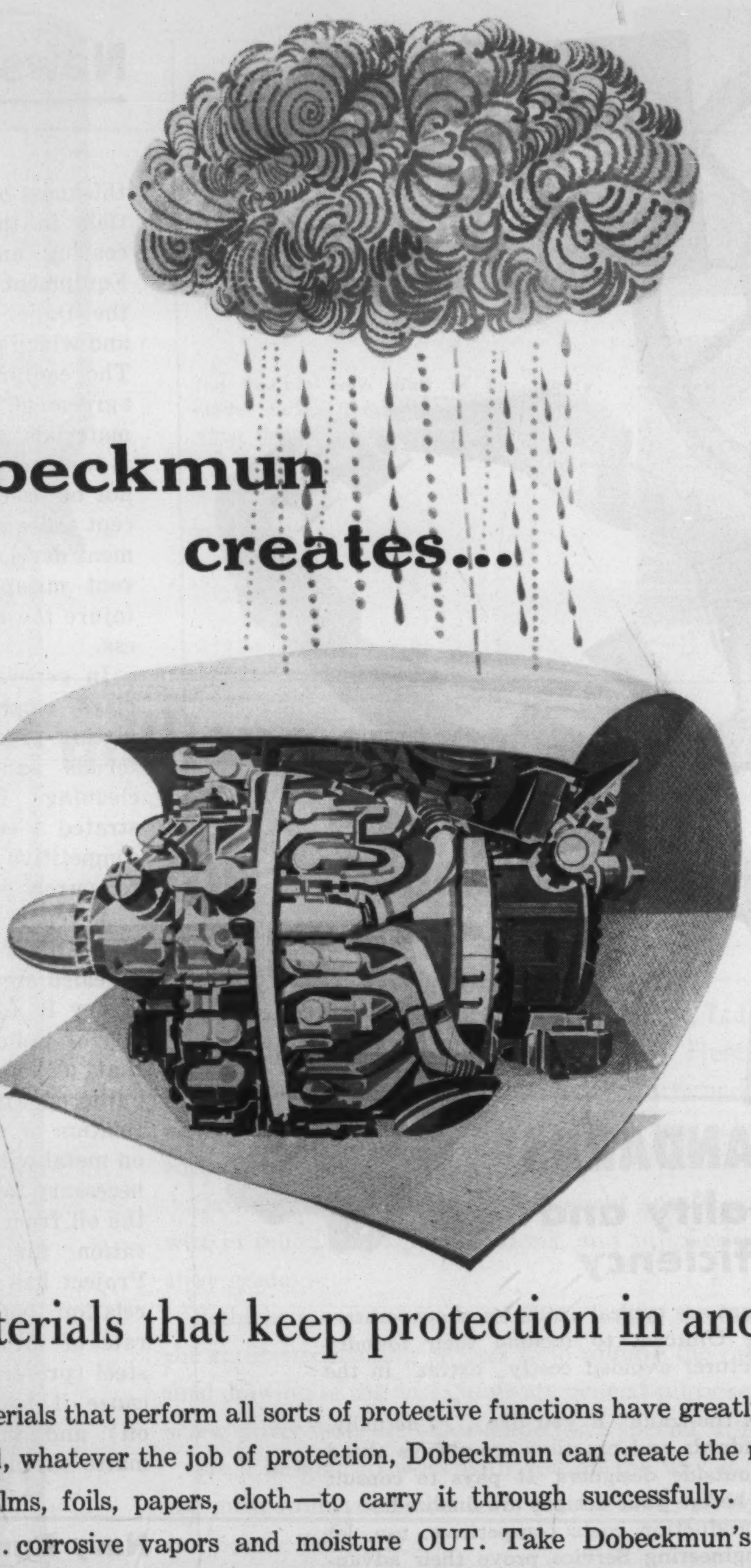
nique may be held up almost indefinitely before the change in large scale production can be justified by test results. Also, the whole field of research on improved corrosion resistant plated coatings is slowed, and the transition from laboratory research to applied production technique is impeded.

Papers

The conference, well attended by members of the electroplating industry, also heard papers on new plating techniques, of which the following are abstracted in the August "Contents Noted" department of M&M: two new plates developed by Pratt & Whitney; ultrasonics in plating, a process which promises to speed plating cycles; a new anodic etch solution; electrophoretic deposition of metallic and composite coatings, a high voltage colloidal dispersion deposition technique, and a report on electroless plating of non-conductors (ceramics).

Other papers dealt with plating beryllium copper, particularly for use with plastics molds; a study of the depth of penetration of hydrogen as affected by the variables of cathodic pickling; the use of radioactive dirt to test cleaning compounds; the effect of chromium deposits on the fatigue strength of hardened steel; the progress that has resulted from development of airless spray painting techniques; several papers on porcelain and ceramic coatings; and reports dealing with the practical techniques of electroplating.

Displays in the electroplating equipment show included a good cross section of the equipment available to industry. Several new pieces of equipment were introduced which drew particular attention, such as the Dermitron, a nondestructive thickness tester useful with a variety of coatings and base materials. The Dermitron is a commercial adaptation of Abner Brenner's circuit developed at the National Bureau of Standards which measures the



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News Digest

thickness of a coating by differentials in the conductivity of the coating and the base material. Equipment for brush plating by the Dalic process was displayed and wide interest was shown in it. The equipment is sold under an agreement which must specify the materials for which the process is to be used. The equipment cannot be used for any purposes except those approved by the equipment developers, who hope to prevent misapplications that might injure the reputation of the process.

In general, the equipment displays emphasized bright nickel plating processes, automated materials handling and ultrasonic cleaning. F. J. Stokes demonstrated a vacuum plating that is competitive with electroplating for purely decorative applications.

A report on Research Project 12—"Oil Spreading Studies" also revealed significant progress. Dr. Henry B. Linford of the University of Columbia told the Society that a body of data has been gathered which shows direct correlation of the oil spreading rate on metal with the immersion time necessary for complete cleaning of the oil from the surface in preparation for electroplating. The Project has obtained general correlation between the spreading rate of oil droplets on stainless steel (preferred as a standard because it is not attacked by the oil) and the cleaning time on matte surface steel.

Navy Running Inspection Course

The U.S. Navy is polishing up its metal inspecting techniques. Personnel of the Material Inspection Service are getting intensive ten day training courses in metals inspection at the U.S. Navy Metals Laboratory in Munhall, Pa.

The courses are limited to an enrollment of 12 students, with one ten day course conducted per month from September through May. All military and civilian per-

Attractive screw-driver kits include an unbreakable plastic handle and a selection of blades for the handyman's pocket.

The flexible wire shaft of this handy model makes it easy to get at screws when there's no elbow room to spare.

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Oxwall is a large user of Bethlehem special-purpose screw-driver wire in round and square sections, and supplied in both carbon and alloy grades.

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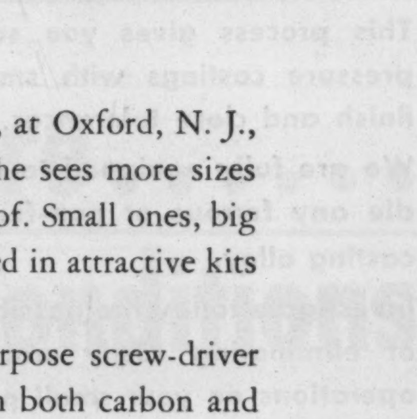

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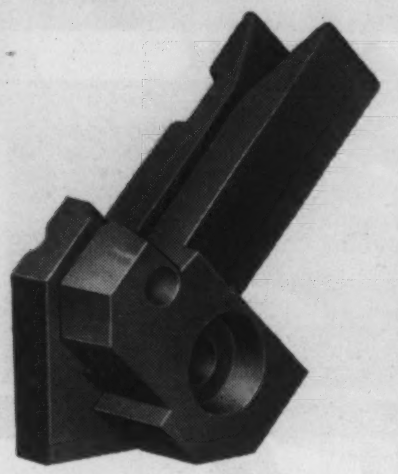
Investment Casting shows the way



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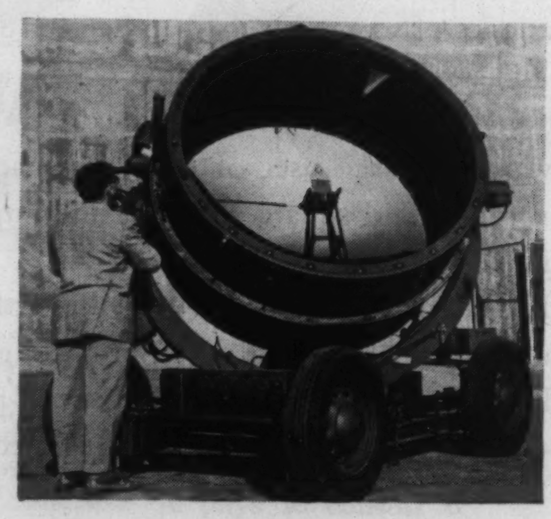
sonnel engaged in the inspection or procurement of metallic materials in any inspection office under cognizance of the Office of Naval Personnel are eligible to attend.

The course includes refresher lectures in specifications, properties of metals, composition of metals, testing techniques, principles of protective coatings, corrosion, welding, radiography, and other related subjects. The Navy has conducted the courses since Oct., 1952. Then the course was for five days only. To date, over 400 personnel have completed the program. According to Captain S. G. Nichols, Inspector of Naval Material, the over-all result of the course has been an improvement in the quality of Navy metals inspection, with benefits accruing to both the Navy and to manufacturers or contractors.

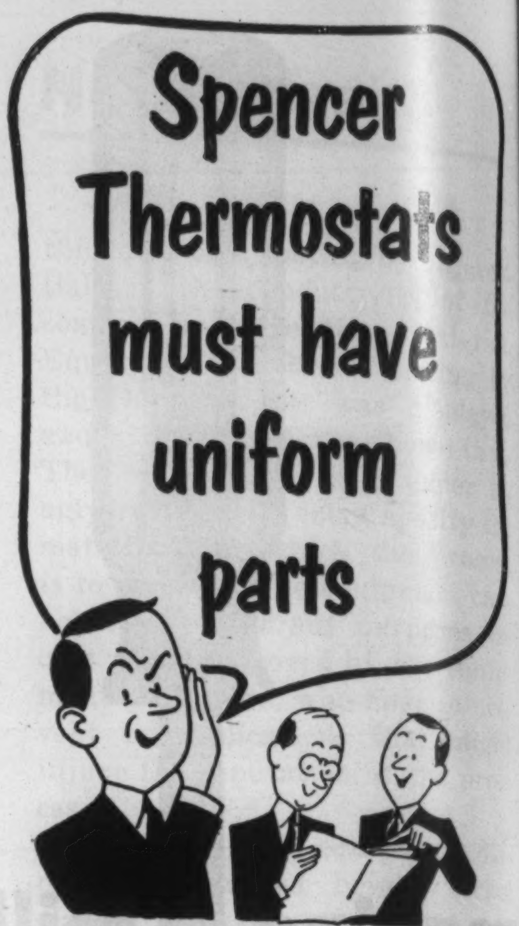
The inspection course was developed and is administered by W. R. Angel, Navy Metals Laboratory Director, and B. B. Rosenbaum, Head of the Metallurgical Div. of the Laboratory.



***Converted searchlight** makes an extraordinarily efficient solar furnace at Convair.*

Solar Furnace From Searchlight

An old war surplus searchlight pointed at the sun on a clear day will produce a hot spot that will melt anything, so say engineers at Convair Div. of General Dynamics Corp. Some time ago the thermodynamics group at Convair acquired a 120-in. solar furnace that worked well on clear days. In-



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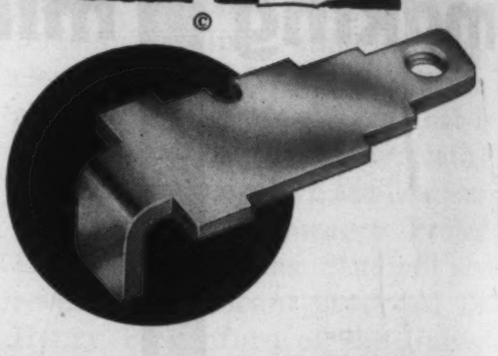

Making the right angle bend on this brass contact terminal was troublesome until Spencer Division of Metals & Controls Corporation turned the job over to Mohawk. We not only stamped and formed the part, but tapped it in the same operation. Mohawk produced perfect, uniform parts at only about half the cost, a yearly savings of thousands in initial cost alone. And with Mohawk's better parts, there's a saving in smoother production and the elimination of rejects.

Mohawk can cut your production costs on threaded stampings, too. Intricate or simple parts are turned out economically and on schedule. Holes are squarely tapped and threads can be held to Class 3 fit. If you have a headache to buck on threaded stampings, pass it to Mohawk for savings in time and money.

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There are 11 HAYNES high-temperature alloys. All have excellent strength at elevated temperatures, good creep and stress-rupture properties, and are extremely resistant to oxidizing or reducing atmospheres. One of them may be the answer to a production or maintenance problem in your plant.

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News Digest

Test specimen *is moved into focal point of solar furnace.*

creased study of the behavior of metals and ceramics under high temperature conditions and heat shock kept the solar furnace busy, so by way of supplementing the big outfit Convair purchased three old searchlights from a war surplus dealer at $400 each. Pointed at the sun, the searchlight's parabolic reflector concentrates the heat rays at a focal point about 3/10ths of an inch in diameter, at a temperature of 7000 F. Two of the searchlight assemblies were equipped with drill chucks as specimen holders, and the third was kept as an auxiliary heat source for use on smoggy days.

The intense heat developed by the bargain-basement furnaces will melt most materials in seconds. Specimens subject to thermal shock will shatter if moved into the focal point quickly.

Only minor modifications were necessary to convert the searchlights into solar furnaces. Engineers removed the arc lighting mechanisms and glass covers. A drill specimen holder was installed in each and adjustment handles were attached so technicians could move the test samples into and out of the focal point.

To use the heat from the operational searchlight, the engineers merely shine it into the mirror of one of the stripped-down (solar furnace) searchlights. An engineer explained, "the mirror doesn't

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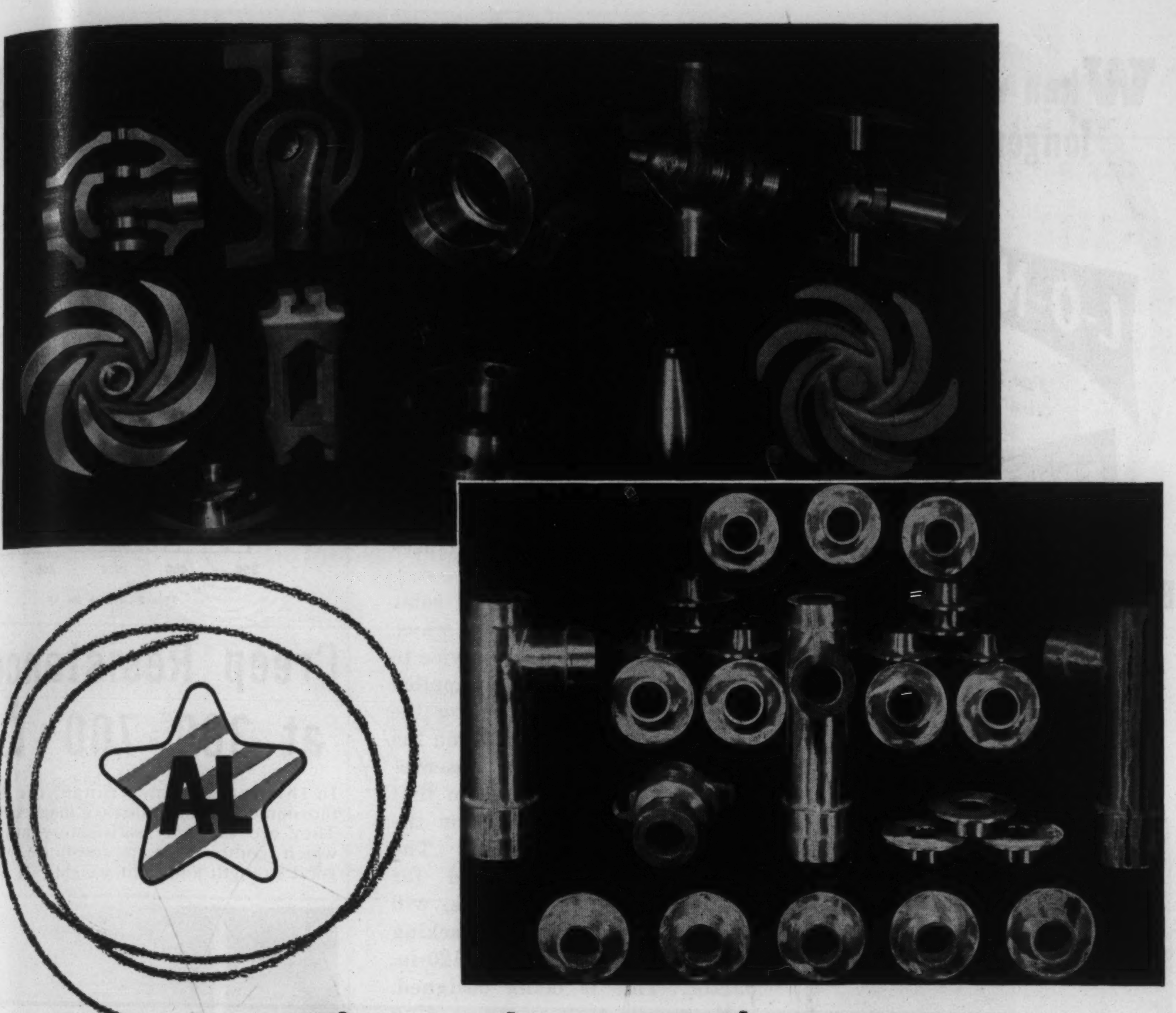

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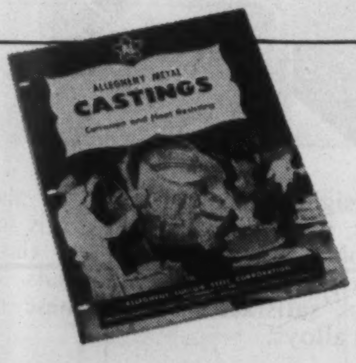

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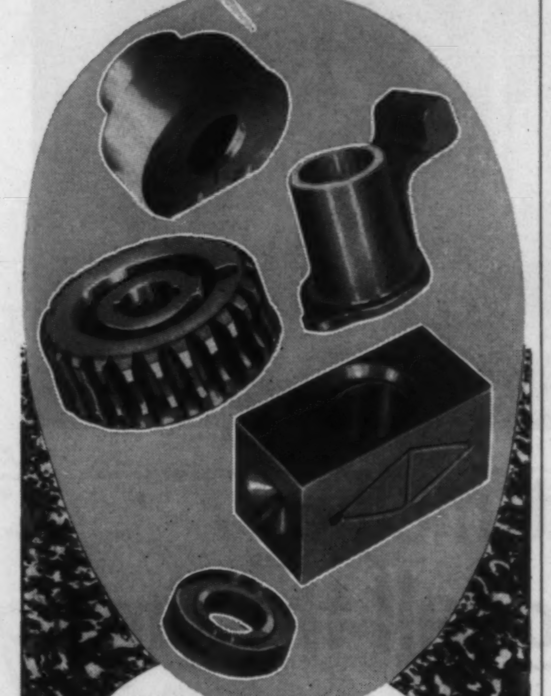

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know whether it is looking at the sun or at another searchlight." Heat from the searchlight alone is adequate for many tests, he said.

The searchlights, while having a focal point diameter .05 of an inch smaller than that of the 120-in. mirror, achieve higher temperatures than the 120-in. instrument, engineers found. Radcliffe explained that the smaller mirrors have a more nearly perfect parabolic curve than the larger solar furnace and their mirror surfaces are more highly polished.

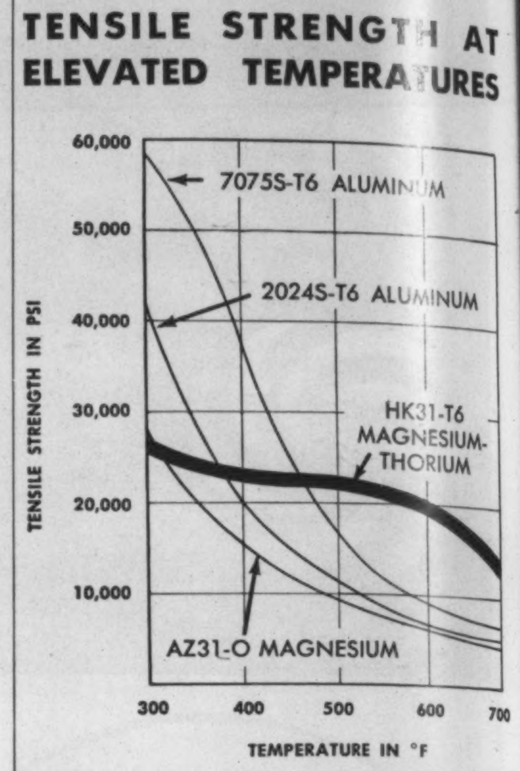
However, both types of solar furnace are useful in special ways. The 120-in. mirror has a device to control the amount of heat applied to a specimen by restricting the amount of sunlight shining on the mirror. It also has an observatory-type timing mechanism that keeps the mirror focused on the sun as the earth moves. The searchlights, while geared for radar tracking of airplanes, will require an automatic sun-tracking mechanism like that of the 120-in. mirror. This is being designed.

Meanwhile, tests are proceeding at an accelerated pace as the thermodynamic engineers focus two of the three mirrors manually.

And in case something should happen to one of the searchlight mirrors, there's always the comforting knowledge that there are spares. Several war surplus mirrors were acquired for $50 each from the vendor who supplied the complete searchlights.

Welding Society Meets in October

The American Welding Society has over sixty speakers on tap for its National Fall meeting in Philadelphia, October 17-21. Welding Society members will discuss carbon dioxide shielded metal arc welding; advances in welding titanium and molybdenum; application of welding to shipbuilding, piping, pressure vessels, machinery, and many other fields. Tech-



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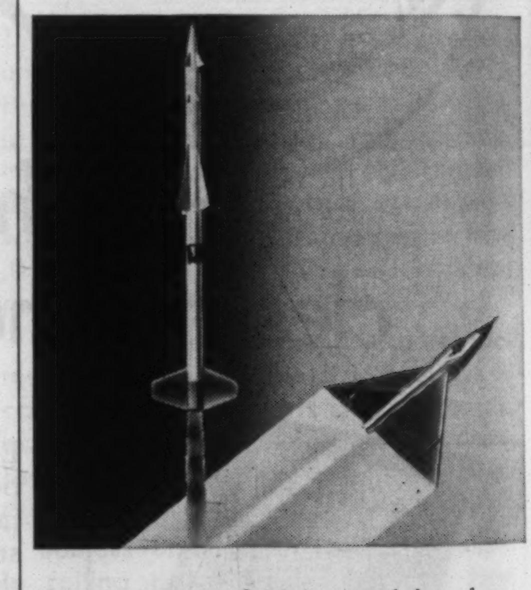

For designers of high speed jet planes, rockets, and guided missiles, this solves a problem. Formerly it was thought necessary to use heavy materials. They are less satisfactory than these magnesium alloys.

Formerly available in the form of castings only, thorium-containing magnesium alloys now come in rolled sheet. B&P's mill produces this sheet.

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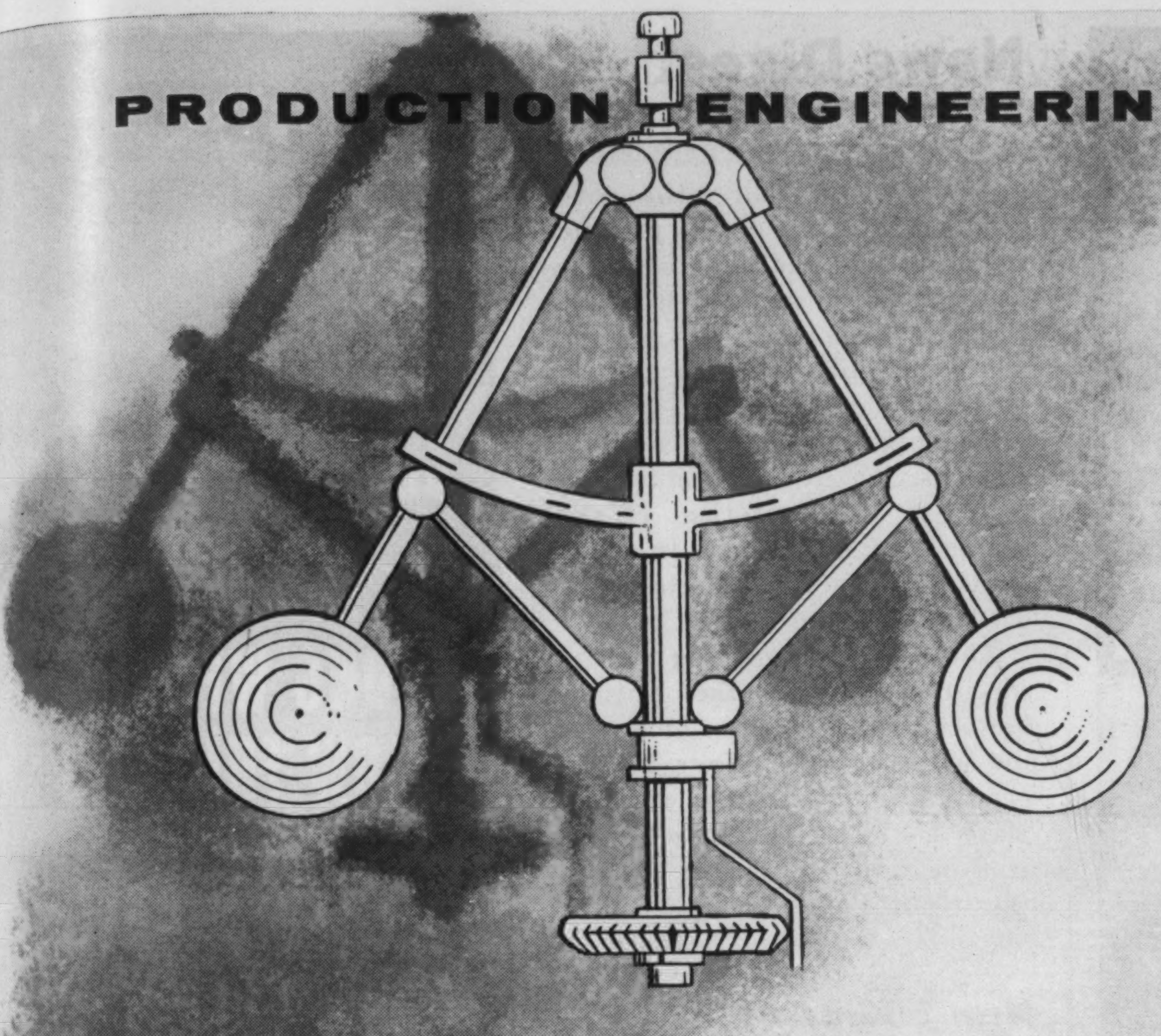
PRODUCTION ENGINEERING SHOW



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News Digest

nical sessions will also cover welding stainless steels, pressure welding rails, and how to use the new powder metal electrodes. Brazing, inspection techniques, and weldability research will also be discussed.

The highlight of the technical sessions, the Adams Lecture, will be "An Interpretation of Research and Experience in Structural Welding" by LaMotte Grover of Air Reduction Sales Co.

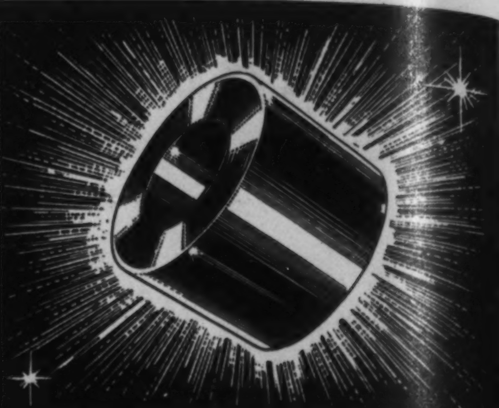
The AWS Fall meeting will run concurrently with the National Metals Exposition, at which welding and cutting exhibits will appear. The Exposition will take place in Philadelphia's Convention Hall near the campus of the University of Pennsylvania.

New Source of Cold Worked Tube

The Tube Reducing Corp. of Wallington, N. J. has announced plans to expand its facilities for manufacturing a special type of cold finished tubing. The company will produce the cold finished seamless tubing in the range of ⅛ in. to 17 in. The tubing, which has improved surface, closer tolerances and better mechanical properties than cold finished tubing previously produced, is made by compression cold working in tube reducers followed by cold drawing to specifications. At present, the size range for this type of tubing is 1 in. to 1-⅛ in.

Tube Reducing recently completed a new plant to increase the size range of compression formed tubing to 17 in. o.d. The addition of facilities for the production of cold drawn precision tubing will provide the broadest size range of this type of tubing available from a single supplier. The company has been engaged in the tube reducing method of cold forming by compression since its first patents were awarded in 1929. They will continue to supply standard and precision compression formed tubing.

(More News on p. 260)



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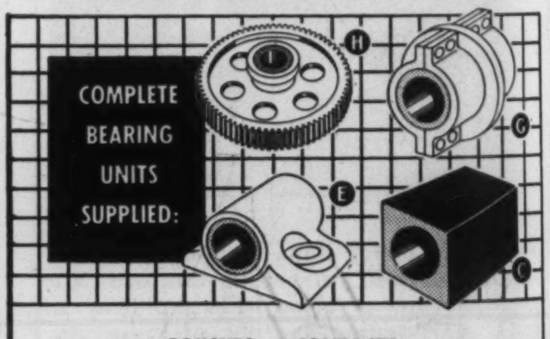

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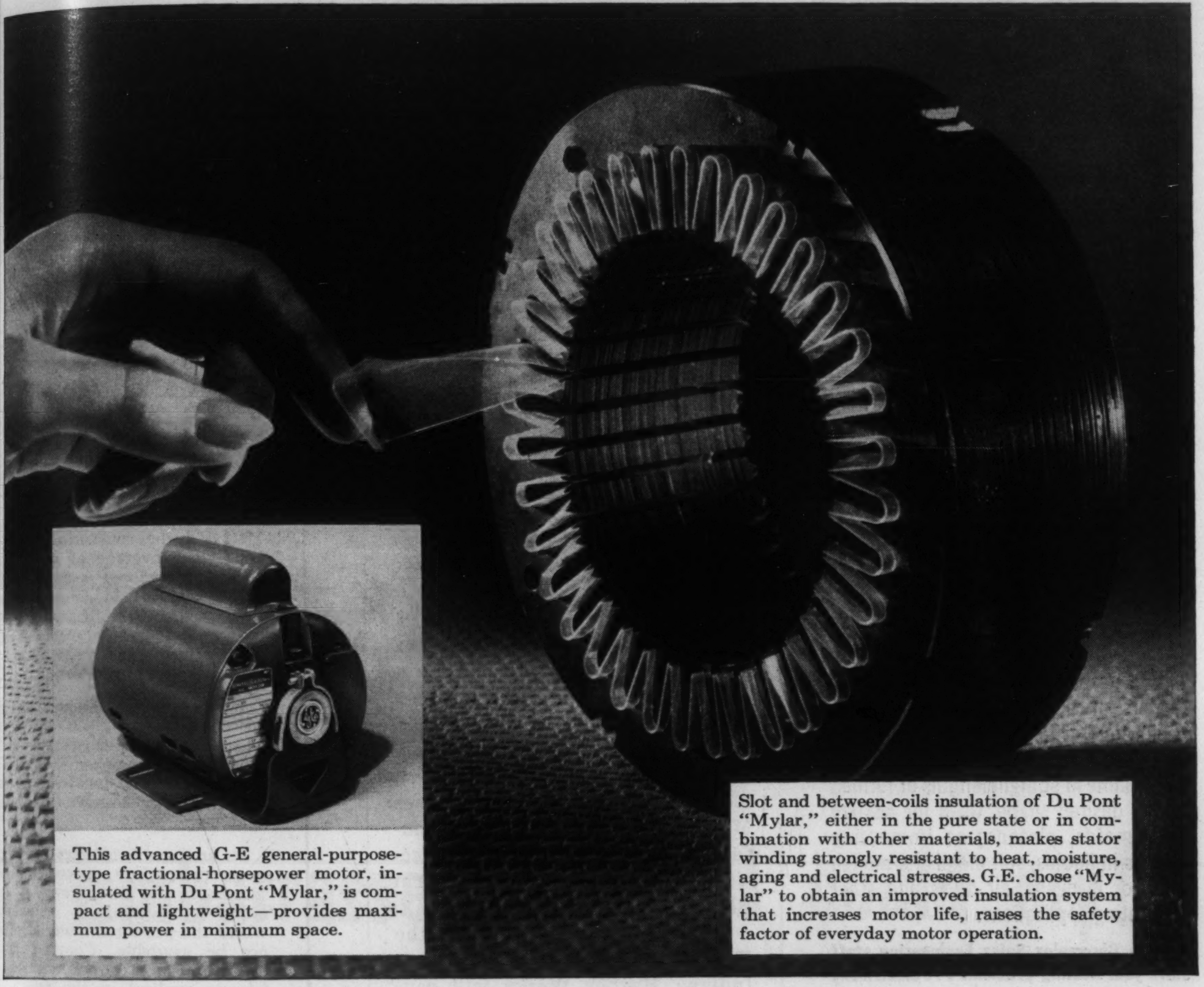
SUPERIOR... Electric Motors Insulated With Du Pont MYLAR*



This advanced G-E general-purpose-type fractional-horsepower motor, insulated with Du Pont "Mylar," is compact and lightweight—provides maximum power in minimum space.

Slot and between-coils insulation of Du Pont "Mylar," either in the pure state or in combination with other materials, makes stator winding strongly resistant to heat, moisture, aging and electrical stresses. G.E. chose "Mylar" to obtain an improved insulation system that increases motor life, raises the safety factor of everyday motor operation.

CHALLENGING to industry: countless opportunities for product improvements with this versatile new film.

Combining high dielectric strength and moisture resistance, Du Pont "Mylar" polyester film helps General Electric obtain a superior insulating system. "Mylar" is now used as slot and between-coils insulation of the G-E advanced motor line—helps make possible a modern, improved type of insulation that increases motor life and insures better motor protection. "Mylar" gives these motors maximum protection against heat, moisture and deteriorants.

These G-E motors are an outstanding example of the way industry is putting versatile "Mylar" to profitable use. "Mylar" is the strongest of all plastic films—has an unusual combination of physical, electrical, chemical, and thermal properties never before available in a plastic film. In a remarkable diversity of fields, Du Pont "Mylar" is making possible better products, lower costs.

It may take only a little creative research to show *you* where you can use Du Pont "Mylar" to develop or improve a product. Mail coupon for free copy of a booklet that gives you the details on this valuable film.

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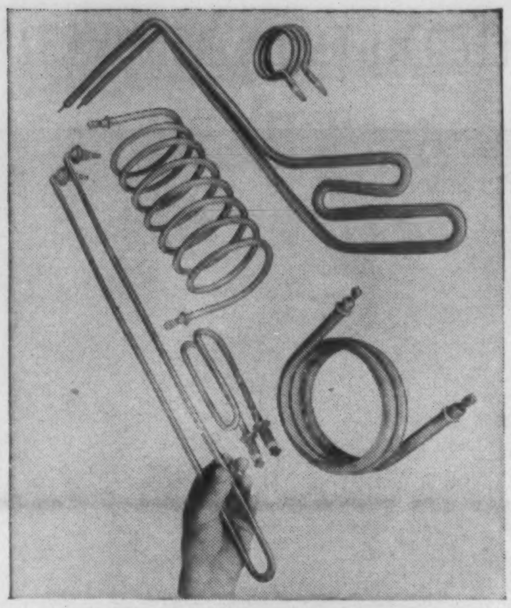

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For more information Circle No. 412

News Digest

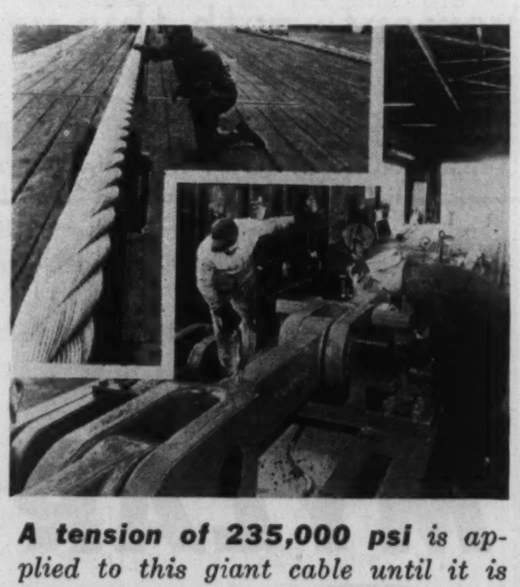
AISE Convention To Meet in Chicago

The Association of Iron and Steel Engineers will hold its 1955 meeting in Chicago's Hotel Sherman, Sept. 26-29. Technical papers will be presented by steel men on operating, maintenance, and production aspects of steelmaking.

The majority of the forty-three papers scheduled for presentation are devoted to the subject matter of steel production and processing. The following papers dealing with properties and heat treatment of steel are also scheduled: *Tonnage Heating by Induction*, by R. S. Segsworth, General Engineering Co., Ltd., and M. C. D. Hobbs, Western Canada Steel Co.; *Effect of Finishing Temperature on the Properties of Hot Rolled Steel Plate*, by Glenn W. Merrifield, Foundry Engineer, Giffels and Valet, Inc.; *Hot Extrusion of Carbon Steel Solid Sections*, by Joseph K. Seyler, Jones and Laughlin Steel Corp.; *Normalizing and Quench and Temper Heat Treatment of Steel Products*, by James MacGregor, York Gillespie Manufacturing Co.; *Heating Heavy Sections—How Fast?*, by Quentin Bloom, Selas Corp. of America.

An inspection trip to the Youngstown Sheet and Tube Co.'s Indiana Harbor Works will conclude the four day meeting.

(More News on p. 262)



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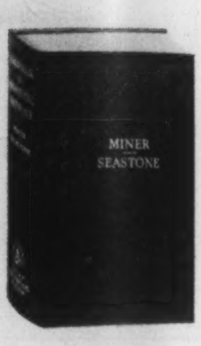
Edited by DOUGLAS F. MINER, Carnegie Institute of Technology, and JOHN B. SEASTONE, Olin Mathieson Chemical Corporation. With 51 contributors.



UNLIKE the conventional handbook, the coverage of this comprehensive volume is not limited to any single field. It provides a single source of authentic reliable information on the materials of manufacturing and construction in *all* branches of engineering.

It is of particular value to the specialist working in an area where several fields overlap—and ideal for the engineer facing materials problems involving areas of knowledge outside his own field.

Its arrangement makes easy the ready comparison of competitive substances and also serves as an index of alternative materials where the preferred material may not be available. Compact and easy to use, it covers all main factors involved in the selection of a material and provides references for information on an almost inexhaustible range of substances.

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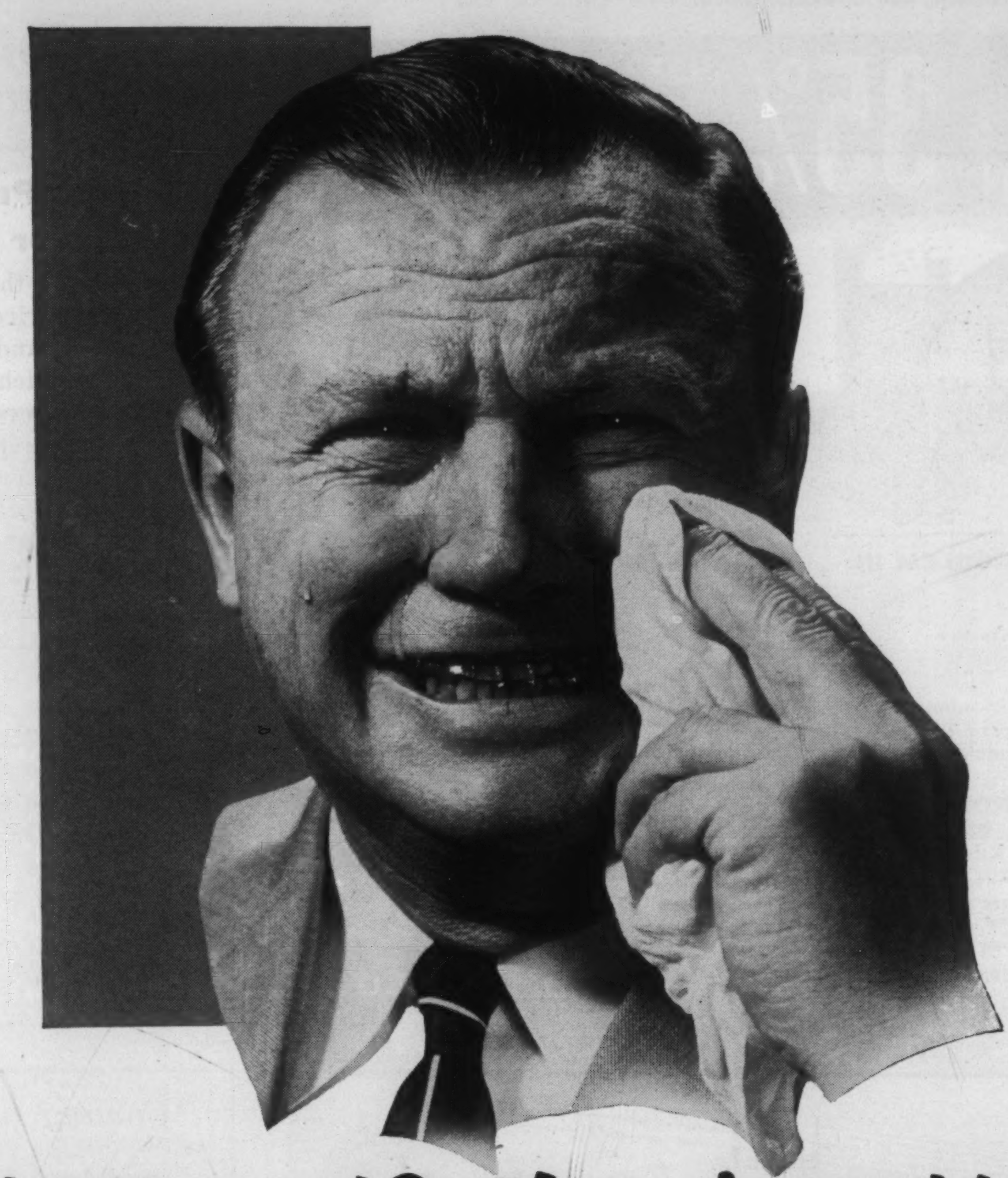

Embarrassed? Man, I could cry!

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"If you've never stopped to count the number of metal cleaning and surface treatment operations in your plant (or the money you might save on them) chances are you'll be shocked.

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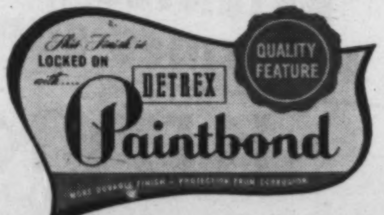

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Salt fog corrosion tests, bend tests, pressure-sensitive tape tests . . . prove the superiority of KEYKOTE 25 as a paint-bond coating. Photomicrographs show the fine crystalline character of KEYKOTED bonding surface, with superior resistance to spalling, abrasion, and impact.

KEYKOTE 25 will provide a tough, dense coating on mild steel at minimum cost.

Write or phone for Bulletin 135 which gives a detailed report on this exclusive patented product producing superior paint bonds.

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News Digest

AEC Sets Prices for Reactor Fuels

Last month, the government revealed the prices for uranium, heavy water, and the leasing cost of U 235-enriched uranium for use in research reactors. Properly qualified researchers will pay $28 per lb for heavy water—used as a moderator for several types of reactors—and about $18.17 per lb ($40 per kg) for pure uranium. For uranium enriched with the reactive isotope U 235 available only on lease, the cost is considerably higher—around $11,350 per lb of contained U 235. By law, no one is allowed to own fissionable material outright—even foreign countries who obtain fuel for research reactors under bilateral agreements with the U.S. can only lease the material.

Coming in October

Nodular (or Ductile) Irons by J. L. Everhart—a comprehensive, 16-page manual on these new engineering materials. Extensive data on properties and applications will show you how you can combine properties normally associated with cast steel with the economy usually associated with ordinary gray cast iron.

Reinforced Plastics Pressure Vessels by M. A. Roun—a report based on work by the Army's Chemical Corps that shows how glass-reinforced plastics can be used to advantage in spherical and cylindrical pressure vessels.

"Tailor Made" Steels by A. M. Hall—an interesting survey of several groups of steels, developed in recent years to meet special needs.